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RIVER TRANSPORTATION*

By A. E. Crockett†

A nation progresses as it utilizes all its resources, whether they be material or spiritual. In our economic fabric there are three predominant fundamentals—namely, natural resources, labor, and transportation, the latter being the bond of the former two. In its basic state it is that force which moves a given object from one location to another.

Transportation began when the first man picked up the first load and removed it from its primeval resting place to another location. As man developed, he sought the aid of noble friends from among the dumb animals. With the continued advance of civilization and the awakening of the human mind, new means of transportation were found. Thus in the early days of our nation, the onrushing waters were made the agency for moving the products of farm, forest and mine. However, with the discovery of other agencies, people turned from water and directed their thought to the railways, and, when the internal-combustion engine reached a satisfactory stage of development, this means of power turned trails and mud-holes into magnificent boulevards, which at no distant date will extend from ocean to ocean, and from the Great Lakes to the Gulf.

All these methods form one grand unit, and every segment of the unit must be equally and fully developed if we are to maintain our leadership in the commerce of the world.

With the study of transportation methods it was startling to find that when the products of agriculture, mine and mill were being denied normal movement of freight, due to the congestion and inadequate railway facilities, there should be so many avenues not utilized in forwarding the products of our nation, these avenues being the broad spreading rivers, particularly of the interior section of our country. Study, if you will, the map of our fair land; see the mighty Mississippi coursing from the northern boundary to the Gulf of Mexico. While it is true that above Minneapolis navigation is not possible, the distance (approximately 1900 miles) from this city to

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the Gulf is so great as to cause one to wonder why, in the growth and development of our nation, this mighty river and its tributaries have not been developed to the point of greater usefulness than at the present time. Probably a little study of some of the magnificent distances will be interesting at this time.

NAVIGABLE DISTANCES ON MISSISSIPPI RIVER

From	To	Statute miles
Minneapolis	St. Louis	676
St. Louis	Cairo (Ohio River)	182
Cairo (Ohio River)	Memphis	226
Memphis	Vicksburg	375
Vicksburg	New Orleans	391
Total		1850

From Pittsburgh, at the origin of the Ohio River, the distances are as follows: 468 miles to Cincinnati, 601 to Louisville, 967 to Cairo, 1193 to Memphis, and 1959 to New Orleans.

Time was when the Mississippi River and its feeders were the only avenues of transportation, save the slow-moving Conestoga wagon and other similar vehicles. Within the memory of our grandparents, did they desire to transport any large volume of tonnage from a section of Western Pennsylvania to Cincinnati, Louisville, St. Louis, or New Orleans, it was by this agency—water. Is it possible, or even probable, that one of the reasons why development of our rivers has not taken place and kept pace with other means and methods of transportation is that engineers have forgotten the possibilities of transporting goods on water instead of always on bands of steel?

I think you will all agree with me that the development of the last century in our country has been due to the fact that we have had engineers—men who have had placed on their shoulders the serious problems of the development of our resources, of all kinds and characters, and, judged in the light of the position that we as a nation occupy to-day, they have fulfilled the trust placed in them. It is just as sure as the sun rises and sets that—because of the lessening of our natural resources, the attitude of many types of labor, and the all-round higher standards demanded—in the working out of the future the engineers of our land will be called upon to render greater and finer service than ever before. As the engineer deals not only with pure

mechanics, but delves into every phase of economic life, one of the greatest things he will have to consider will be the question of transportation. There is no more fertile field open than that of transportation by water. It is the most economical agency for transporting materials, and, as such, unless we utilize it, we are bound to pay the penalty for our neglect. Not a week passes but that the public press has an announcement that a group in some section of the country has appealed for a reduction in freight rates, and has turned to the Interstate Commerce Commission, or some other governmental agency, demanding that it take such action as will force the railroads to a lower level than that now in existence.

The railroads have done a magnificent work in the past in doing their part in the development of our nation, and there is no doubt but that in the future they will be called upon to do even more than in the past; but a railroad cannot exist save as it is able to pay the wage of its employees, to repair the wear and tear of traffic, and to arrange for the mending of the present equipment or for funds to purchase new equipment for that already worn out. In addition, the railroad must be able to give a satisfactory return to those who have loaned their money, either in the form of purchased capital stock, bonds or borrowed money from the bank. Then, too, as railroad companies have hopes of enlarging their usefulness, the same as any other business concern, they should be permitted to build a surplus for the rainy day—something that, at the present time, does not seem possible. If, therefore, the railroads should receive returns to cover all these items, and present rates will not afford them the opportunity to meet these demands entirely, how can we look to them for a reduction of our freight rates?

On the other hand, there is no doubt but that we must find a way of moving some materials at a lower charge for this service. Possibly one of the best answers to this is to cite an order which was placed by one of the railroads with a firm in Pittsburgh only a few months ago, and which stated on the order, "Must be shipped only via water," to a given point, which was their rail head, the railroad figuring thereby that it would save several dollars a ton. This order called for not only one carload of material, but practically a barge load, which, in these days, means from 500 to 750 tons.

Again, according to the report of the Federal Barge Line (Mis-

sissippi-Warrior Service) up to October 31, 1922, they had transported 16,610,000 bushels of grain at an average saving in freight of 2 1/3 cents a bushel. The bulk of this grain movement originated on farms in the northern and western states, principally in Iowa and Nebraska, being shipped by rail to St. Louis or Cairo and there transferred to modern steel barges and conveyed south to New Orleans, where most of it was exported. In dollars and cents, this meant that the farmers who shipped grain in this manner kept nearly four hundred thousand dollars in their pockets, thanks to the low rates on water transportation. Northbound, the same water transport agency carried several hundred thousand tons of such commodities as agricultural implements, farm wagons, sugar, molasses, salt, fertilizer, binder twine, wire fencing, etc., at an average freight saving of $1.30 a ton. These commodities went to the farmer, thereby enabling him to increase his purchasing power, and at a time when he most needed help. To carry it just a little farther—at a time when the manufacturer needed just the additional demand to turn the tide for him and his employees.

As already indicated, there are transportation agencies other than rail or water, the most important being the motor-truck, on the highways. Go where you will in our land—whether it be on the Lincoln Highway, the Dixie Highway, the Roosevelt Trail, or off in the plains and mountains of Wyoming and Montana, or into the oil fields of Texas—and you will find the motor-truck and the automobile. Because of this, the American people are demanding more and better roads, with the result that they are building them mile on mile, either through state aid or by the aid of our national government. Aside from hearing a howl here and there from the railroads about compelling them to pay taxes to build up competitors, little is said by the "dear public" other than words of approbation.

There is one very marked fact about railways and highways—you can build them in any direction you desire. On the part of one a right of way is secured; on the part of the other the community decides where the road will be, and they go ahead and condemn the necessary property in order to fulfill the wishes of the community. As a matter of fact, the railroads have an equal right of condemnation; but, did you ever stop to realize that when it comes to the waterways there is only one channel for you to follow, and that is that channel which was cut out by the Divine Creator for carrying away the wastes

of the land and the excess rainfall, and to bring cheer and comfort to the dirty and thirsty. This fact, and many other citable reasons, prove to your speaker that these rivers must have a tremendous value, because the United States government says distinctly that no one shall have control over the navigable waters of the land save the government itself; and, due to this fact, the government alone is the agency whereby improvements of the navigable watercourses may be made. It is to this government of ours that we must look for the improvements that are now so absolutely necessary for the complete utilization of the most economical transportation way in our land.

But enough of generalities. Let us get down to our own immediate community and see what waterways mean to us. Sometimes it pays to repeat figures. Sometimes it pays to look back into the past in order that we may count our blessings of to-day with a greater assurance and pleasure. It was not so many years ago, as we reckon time, when a few men, realizing the value of the little Monongahela River, sought a charter to retard the flow of water, to create pools, to establish locks, so that traffic over this stream might be continuous throughout the years. Their vision, some said at the time, was faulty, but, like many another sturdy son of the Anglo-Saxon race, they saw the possibilities, with the result that the returns from their investment were many times more than could even have been dreamed of; in fact, became so large as to cause comment in the community. In addition, the United States government, seeing greater national benefits, purchased these properties and declared them free for all the people.

Some of you may think that this declared freedom was only for the benefit of the citizens of Pittsburgh and those in the Monongahela valley, and, possibly, a short contiguous territory lying to the north, south and southwest from Pittsburgh. On this stream in the year 1920 there were carried over 20,000,000 tons of coal, and, according to the figures given out by the Chamber of Commerce of Pittsburgh through *Pittsburgh First,* the saving was from 80 to 90 cents a ton, and (according to my mathematics) this method of transportation meant a saving of $16,000,000. Was it the citizens of Pittsburgh alone who benefited by the saving? We all know that the selling price of goods of any character represents three factors—raw materials, labor, and transportation. This cost is grouped and a normal profit added thereto. Consequently, if any one of these three factors

making up the cost has an element of saving, this element is transmitted ultimately to the people as a whole.

There is another river beyond, which we call the Ohio—that river which to-day spells more for the continued success of Pittsburgh than any other agency we now have at our door. This assertion is made on the basis of the statements I have previously made in this talk—that water transportation is the cheapest transportation for handling materials. The success in moving steel from Pittsburgh in October, 1921, opened a new field and broadened the vision of every manufacturer in this section. The dreams of men who laid the foundation of our industries were to utilize this river. The men that dreamed these dreams incorporated them in their vision when they started to develop; and the influence of their vision has caused their sons and their sons' sons to see the greatness of the present opportunity to utilize an agency right at our door to help in solving one of our vital national problems.

The one influence retarding the success of this undertaking in the past has been the fact that continuous traffic throughout the year was not possible, but for the future this will not be so, provided we of this section and every other section of our land keep our eyes wide open to see that the necessary control is gradually installed along the river; that is, new locks which will make a nine-foot stage to Cairo continuous throughout the year. This being fulfilled, then the future of the Allegheny valley, the Monongahela valley, the Ohio valley, the Mahoning valley—all the valleys that are contiguous to this river—is assured.

The realization of all the foregoing has already caused large appropriations to be made for extensive terminals, river steamers, and barges. In fact, our engineers have designed new power-boats and barges.

In transporting materials over our inland waterways, up to the present time, practically two types of barges have been used—the open-hull barge and the covered flush-deck barge. In the past, these were constructed wholly of wood, or of wood with steel reinforcements, but lately they have been made wholly of steel.

As a digression, there is one little incident your speaker would like to relate. In the year 1856 William Webb, one of the great shipbuilders of the Atlantic coast, had a very heated argument with his

naval draftsman, Henry Crockett—who, by the way, was my grandfather. The point under discussion was wood ships and iron ships. William Webb told me personally of this instance, and therefore I feel at liberty to give it its full weight and worth. Webb contended that an iron ship would have very little buoyancy, that the weight of the vessel alone would cause it to settle so deeply into the water that it would impair its cargo-carrying value. On the other hand, my grandfather contended that the buoyancy of the iron ship would be better than the wood ship. To settle the argument my grandfather built a hull out of old Welsh plate and, in the testing tank at the Webb shipyards, it was matched with a wood hull of similar design. Much to the chagrin of Mr. Webb, he had to admit that the iron hull had greater buoyancy, and then and there declared that the ship of the future would be an iron vessel. As to the absolute fact of the ship's model being made of Welsh plate, I may say that as a boy I had this as a toy, sailing it many times on the waters in my own old home town.

Thus the prophecy has more than been fulfilled, and to-day we are not only constructing a steel barge, but of a design that we believe will afford greater protection to the cargo and add to the towing qualities and to its general usefulness.

In designing a barge, engineers have several main points to consider—the cargo to be transported, the waters to be traversed, the protection of the cargo from the elements, and the average speed desired. With these points before them, our engineers settled upon what we designate as the gondola barge and the box barge for the transportation of steel products over the interior waterways. Fig. 1 shows these two barges tied at the river bank. In construction these vary from the usual type in that the deck, instead of being flush, is depressed or sunken.

Fig. 2 shows a top view of the box barge, with hatch coverings in place; also a side elevation.

Fig. 3 shows a longitudinal view of the gondola barge, which is the same construction as the box barge, except that the superstructure above the flush deck line is omitted.

Fig. 4 shows half the cross-section of the brace frame, and half the cross-section of the interframe, indicating the thoroughness of bracing for the strains to which a vessel of this character will be subjected. In addition, to insure the safety of the vessel and its cargo,

collision bulkheads are provided at either end, as well as two additional bulkheads, placed equal distances fore and aft; and all these co-ordinate with a longitudinal bulkhead, which not only serves as a water safety agency, but also materially adds to the strength of the barge. All these have been planned, not only for safety and strains, but from a buoyancy factor.

Fig. 1. Gondola Barge and Box Barge.

To reduce the resistance of water while the barge is being towed, the rake of the bow and stern has been increased over that generally employed in barge construction.

To lessen wind resistance, the sunken deck permits a lower cover. Naturally this produces a shortening of the straight-line clearance at the eaves of the roof. This is overcome by a hinged hatch cover, easily handled, as shown in Fig. 5. This, with the sliding door, gives adequate clearance for handling the cargo.

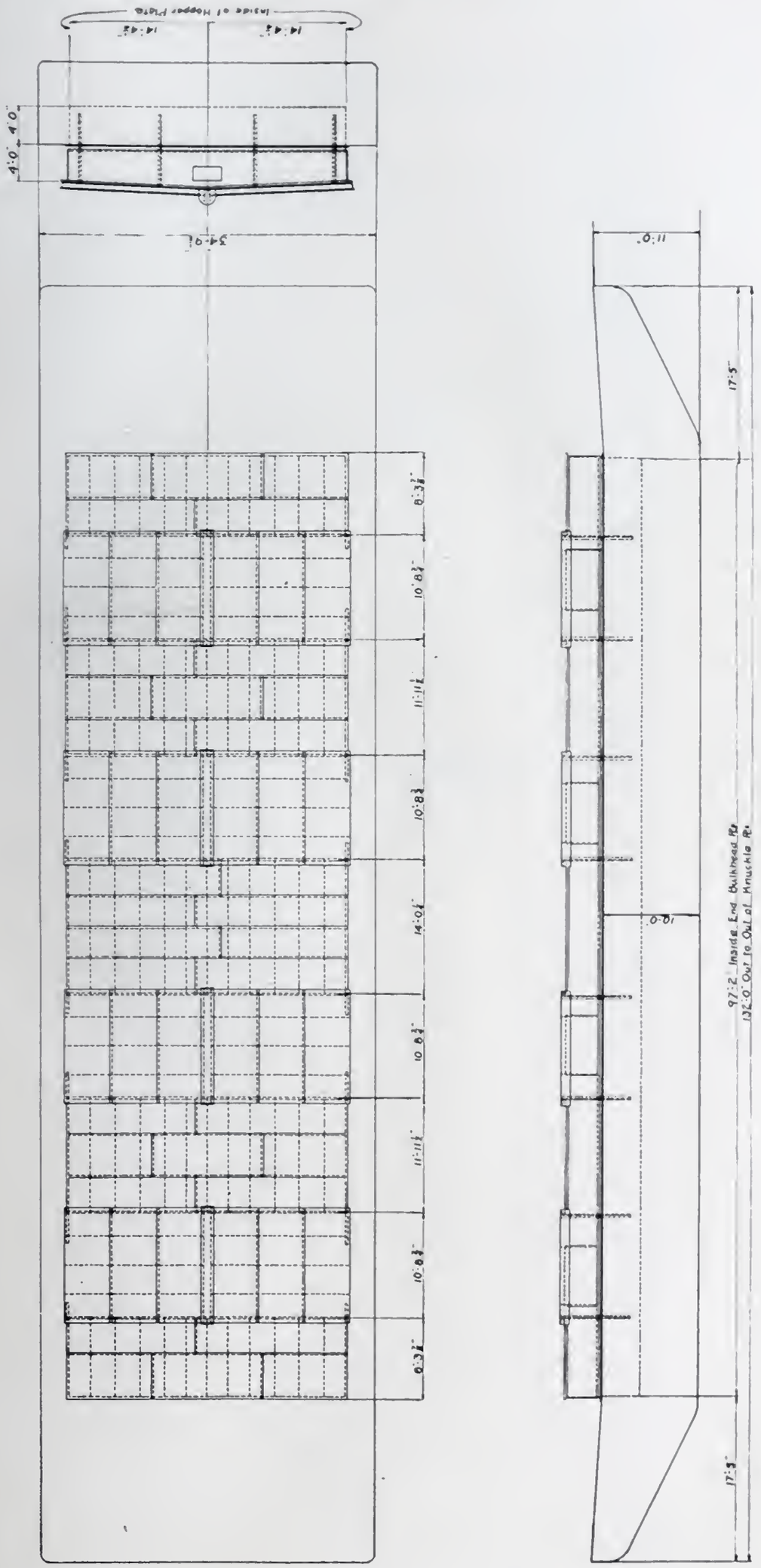

Fig. 2. Box Barge.

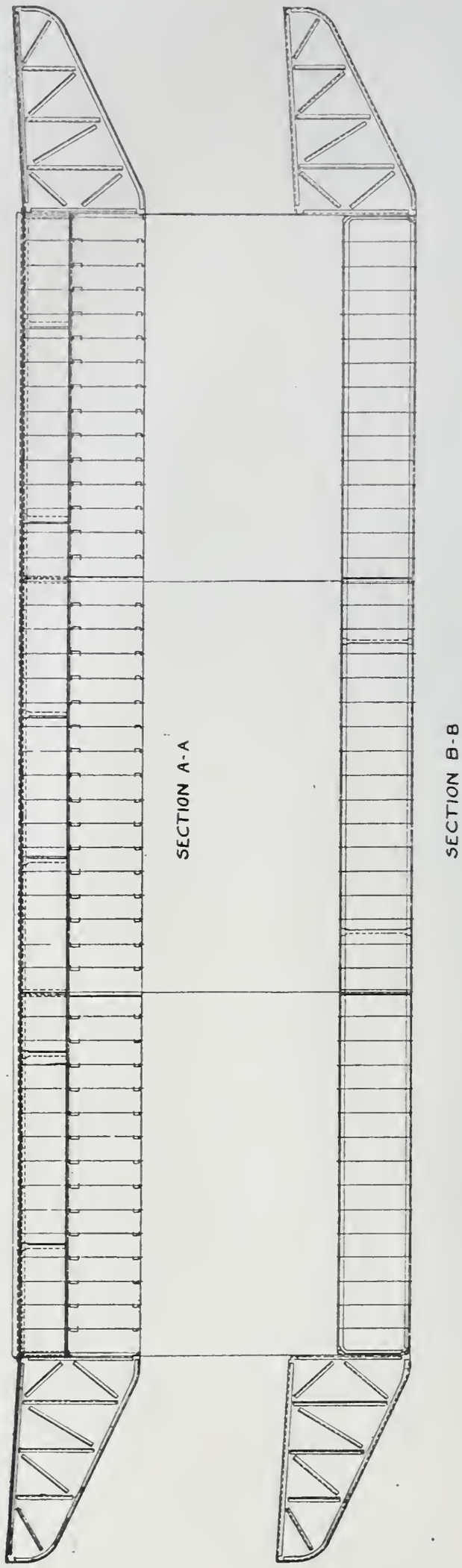

Fig. 3. Gondola Barge.

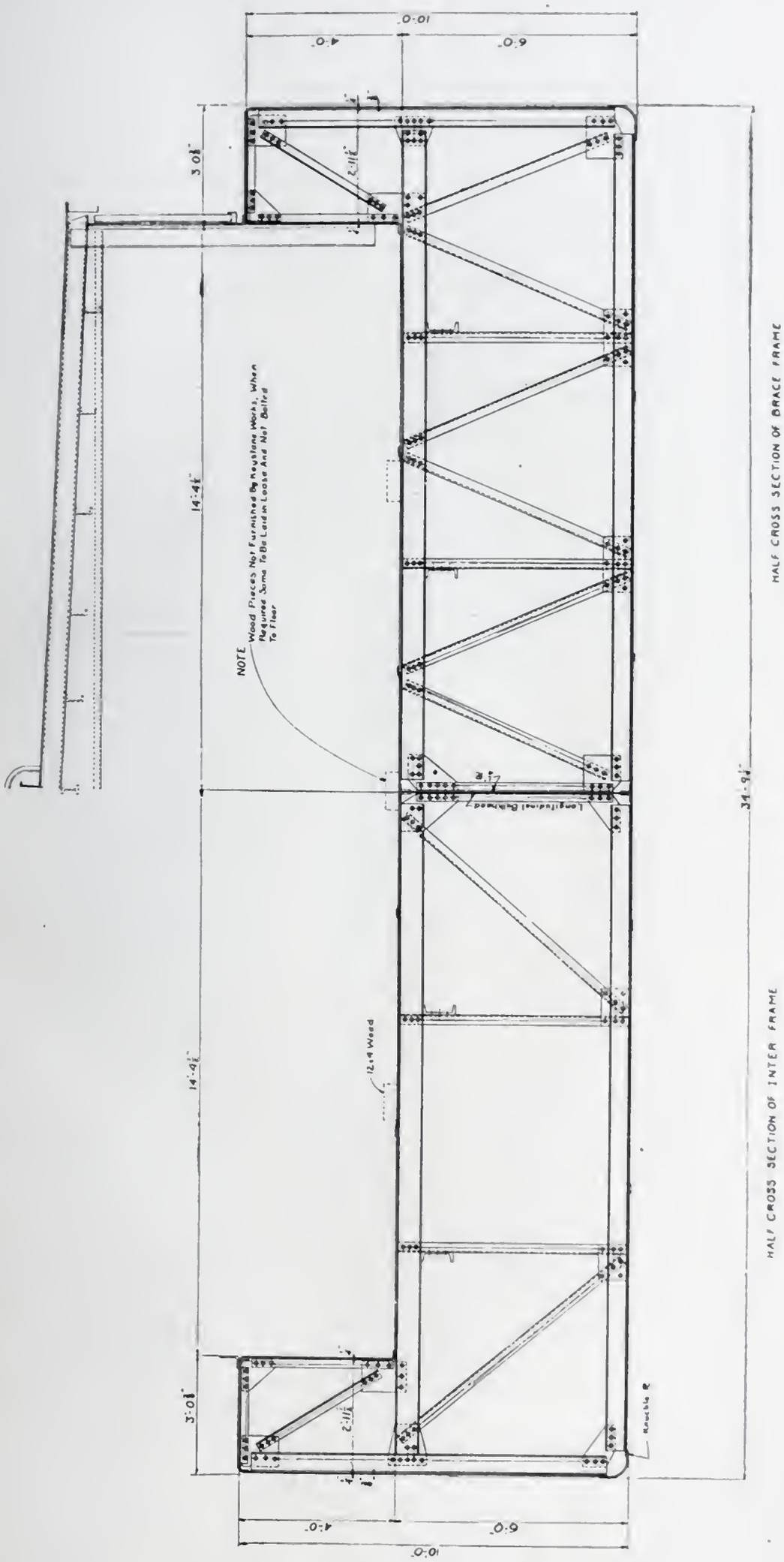

Fig. 4. Brace Frame and Interframe.

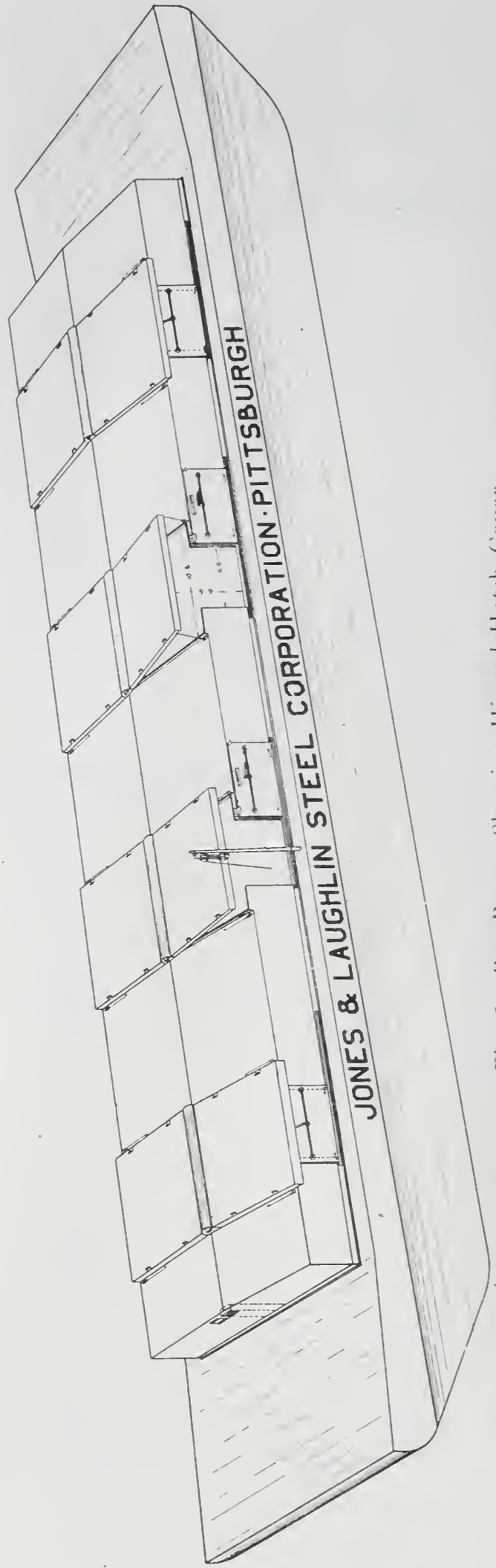

Fig. 5. Box Barge, Showing Hinged Hatch Cover.

DISCUSSION

MR. MORRIS KNOWLES, *Chairman*:* May I ask as to such things as bulk freight, coal or wheat for instance, how long a distance must water transportation be in order to use such transportation advantageously as compared with rail?

MR. A. E. CROCKETT: I do not have any definite figures on that. One of the river captains at Cincinnati seems to feel that Cincinnati is one of the first points down the river in the handling of bulk traffic. At the 1922 meeting of the Ohio Valley Improvement Association, in discussing that point with a gentleman from Louisville—Mr. Rose, I think—he stated that he believed Louisville is one of the first points. You will see, therefore, a divergence of opinion.

There is one fact, however, of which we must not lose sight. It is not the question of the saving to any one individual community, but to the nation as a whole.

MR. GEORGE H. DANFORTH:† I would like to call attention to the fact that it is probably a question of loading and unloading facilities. I am sure that the handling of coal for fifty or sixty miles could not be successful unless there were good loading and unloading facilities; and I think the same thing would carry through with regard to other products than coal. Is that right, Mr. Crockett?

MR. A. E. CROCKETT: That is right.

MR. WINTERS HAYDOCK:‡ I had not expected to speak on this subject, but perhaps I might make a little contribution on account of my familiarity with the history of the St. Louis river terminal. The speaker of the evening several times referred briefly to the Mississippi-Warrior River navigation undertaking of the government. Perhaps a little more discussion of that magnificent experiment which the government is now making would not be amiss in connection with a paper on river navigation.

*President, Morris Knowles, Inc., Pittsburgh.
†Structural Engineer, Jones & Laughlin Steel Corporation, Pittsburgh.
‡Chief Engineer, Citizens Committee on City Plan of Pittsburgh, Pittsburgh

It may seem strange to refer to navigation on the Mississippi as an experiment. We know navigation on the Mississippi began more than a hundred years ago. About fifty years ago it was a most tremendous activity; yet to-day the fact remains that this barge line enterprise of the government is an experiment.

Referring again to the St. Louis terminal, which made possible this undertaking by the government, I would like to correct a slight error which the speaker of the evening made. That terminal was built by the city before and during the war, not by the government during the war. Not including the Memphis terminal now under construction, it is probably the largest and most expensive river terminal in the country. It is provided with a complete mechanical equipment for the handling of freight. The dock is a magnificent reinforced concrete structure about 890 feet long. Its deck is 42 feet above low water. It must be remembered that at St. Louis there is a variation of 40 to 42 feet between maximum low-water and high-water stages—very much more than we have to contend with in Pittsburgh. The difficulties in building a river terminal on account of that variation were rather great. They had to provide for a vertical lift of at least 40 feet. The reinforced concrete dock is, in effect, a quay wall holding an earth fill behind it, and on account of the great height to which it was necessary to build it, its construction was expensive.

Some years ago the business men of St. Louis formed an organization for the purpose of promoting river navigation on the Mississippi. There were some very enthusiastic men there who believed we could go farther than more practical men thought we could go. The slogan, "Eighteen Feet Through the Valley," was adopted by these men. This meant that they were working for an 18-foot channel from St. Louis to New Orleans. Those who have studied river control know that an 18-foot channel maintained in the Mississippi valley would be almost a financial impossibility—not an engineering impossibility, but so costly to maintain that it would absorb any possible saving that might be expected from river navigation. So they gave up the 18-foot idea and concentrated their energies on the insuring of about a nine-foot channel and on building what they thought would be an adequate terminal at St. Louis. Finally they did succeed in getting the necessary money to start the terminal—$250,000 at first. Later on, more money was provided, and St. Louis spent altogether $700,000 for its

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river terminal. Then the war came along. The terminal was not finished at that time. The equipment had not been completed. The government helped out to a certain extent and the terminal was put in operation by the government as a part of its barge-line project, to relieve the congestion on the railroads. That service was continued after the war, the government giving the city of St. Louis a certain tonnage rate on freight handled over the terminal—about 20 cents a ton, I believe. I understand St. Louis is now receiving a very good return upon its entire investment in the terminal.

Again referring to my use of the term "experiment," in connection with this barge line, I want you to remember that this enterprise in which the government is engaged is rather different from water freight handling enterprises which the speaker of the evening referred to as having been undertaken recently by certain Pittsburgh corporations. It is not a bulk freight handling proposition entirely. There will pass through St. Louis an amount of freight relatively small, as compared with Pittsburgh tonnage, of the class which the speaker referred to as being so successfully sent from Pittsburgh to Mississippi points. It is a miscellaneous freight handling proposition—an attempt to duplicate the functions of a railroad system on the river. To-day that is an experiment, but we hope it will be successful. The indications are that it is. I think every one interested in the subject is optimistic, and I think that perhaps after this experiment has proved itself practicable, river navigation will be finally set upon its feet.

Mr. F. W. Hammil:* The cost of handling freight for short hauls was mentioned a while ago. On the Warrior River, in Alabama, a standard package container is loaded by the shipper, and hauled to the barge landing, where it is handled at a much lower cost than if the packages were handled separately. Is such a container used in the Pittsburgh district?

Mr. A. E. Crockett: I do not know of any such container for handling traffic out of Pittsburgh.

Mr. C. A. Brandt:† The Engineers' Society of Western Pennsylvania is indeed indebted to Mr. Crockett for the most excellent

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†Chief Engineer, Superheater Co., New York City.

paper presented by him this evening. The principal reason that water transportation, although one of the oldest means of communication in this country, has not made the same progress as some other industries, is because of the most efficient and excellent manner in which the railroads have taken care of the urgent demand for rapid movement of goods and passengers. Under this severe competition, river transportation has been neglected. It is believed by many economists that the railroads have come up to the saturation point in their ability to handle traffic, and that a great deal of heavy and bulky material can be moved more economically on the rivers.

The speaker suggested as a question that possibly one of the reasons river transportation had not progressed as fast as the railroads and other industries was because of the failure of the engineers to develop not only the channels, but also the terminals, the containers and motive power necessary to the transportation of the freight. That may be true, but I doubt if this is a fair question. Experience has shown that the engineer is, and has always been, ready to tackle any problem that is found to be economically sound, and successfully solve the difficulties that present themselves. I believe most people will agree that the development of river transportation has suffered from too much politics, and the time will soon come when the railroads will realize the absolute necessity for river development along efficient lines for the welfare of the people of this country, and consider it as an aid, rather than a competitor. The question of taxation of publicly built and maintained waterways is the same as that of highways, and will, no doubt, be solved to the ultimate welfare of all concerned.

The speaker has shown us most enthusiastically a very interesting view of the possible future of river transportation, the development of waterways and terminals, as well as the barges that are to carry the freight, but we have not heard anything about the motive power that is necessary to haul the barges up and down the river. A prominent railroad president stated recently that "the heart of the railroad is the locomotive" and to have a good railroad you must have powerful and efficient locomotives—the best that can be built.

The motive power on the rivers unquestionably is of just as great importance here as the locomotive is for the railroads, or the engine for the automobile or the aeroplane, and here is a problem that has been neglected just about as much as the rest. As an engineer I have

always been interested in the various fields of engineering—particularly that of transportation—but I must confess that until recently my knowledge of river transportation has been quite vague; like that of many others, I believe, limited to the wisdom gained by reading Lincoln's early life, "Huckleberry Finn," and other stories of river life. As the company with which I am connected is interested in improving the efficiency and capacity of steam-power plants, we began an investigation of the towboats on the rivers a few years ago, to see if their efficiency could be improved by application of superheaters.

At first we thought these boats were crude, inadequate and very inefficient, and wondered how engineers could allow boats of that type even to be operated. The boilers were found to be about four feet in diameter and 30 feet long, with half a dozen flues, and a long-stroke engine. They certainly looked very crude and antiquated. We made a study of a boat to give greater efficiency, equipped with what is considered modern power equipment, but when we got into it we found that peculiar operating conditions on the river had made it necessary to use equipment of this character. We found that the boiler feed-water was about 50 per cent. mud and a water-tube boiler would be impracticable; it was necessary to have a boiler of the kind used, so you could send a man to shovel out the mud. The engines on towboats are long-stroke engines—six-foot or eight-foot stroke, and operated with a long cut-off, 75 to 80 per cent.—but as they were found to be of very good design with poppet-valves, the application of a superheater immediately suggested itself as a means for a large increase in power, as well as efficiency.

Right here I might state that the steam locomotive some fifteen years ago had reached the limit of efficiency and capacity, because at that time saturated steam was used and the consumption of the saturated-steam engine was so great that it was impossible to get sufficient steam to increase capacity. About that time high degrees of superheat were experimented with and developed, and the wonderful improvements accomplished by the use of high superheat of 250 degrees in the locomotives can be visualized when it is considered that in the last 12 years some 45,000 locomotives in this country have been equipped with high-degree superheat of 250 to 300 degrees. The application of superheater locomotives practically revitalized the railroads. A number of railroad presidents in their annual reports have

stated that hauling capacity has increased 15 to 20 per cent., with an actual saving of from 35 to 40 per cent. in coal and 25 to 30 per cent. in water. The greatest gain, however, is increased horse-power, as it is possible to get an increase of 25 to 45 per cent. in the sustained horse-power capacity with the same weight and the same size boilers. The use of high-degree superheat on river towboats will do the same, and in order to make a success of river transportation you will have to develop a higher capacity and efficiency. I do not know what other improvement can be made in the machinery on account of the difficult operating conditions, but the superheater has certainly effected large savings and increased power in an existing river towboat.

We installed a superheater giving 250 degrees of superheat on the river boat *Huntsville,* owned by the Nashville, Chattanooga & St. Louis Railway. Careful tests were made, and the average saving obtained in fuel consumption on that boat was 40 per cent. The coal consumption was actually cut in two. In addition, the speed of the wheel was increased some 10 per cent., and that cut down the time about half an hour on a five-hour run. Probably they will superheat all their boats very shortly. Another large boat on the Ohio River was equipped with superheaters—the *Ella Richardson,* with 250 degrees superheat—and the same excellent results were obtained.

What I have said here is just a suggestion as to what can be done in one direction, at least, to improve the river transportation machine; and, as it may be of interest, I append the following abstract of a test conducted under the direction of Mr. C. M. Darden, mechanical engineer of the Nashville, Chattanooga & St. Louis Railway, on the steamer *Huntsville.*

STEAMER *HUNTSVILLE*

OBJECT

The object of this test was to determine the fuel and water consumption, distribution of steam, and valve setting of engines and also the amount of superheat obtained with superheater.

DESCRIPTION

Wooden hull, 137 feet long.

Boat, overall, 159 feet.

Beam, 26 feet; over guards, 27 feet 4 inches.

Depth at bow, 5 feet 8 inches; midship, 4 feet 9 inches; stern, 5 feet 4 inches.

Boiler deck, 126 feet in length, 26 feet in width and 9 feet 7 inches high.

Coal space for 500 bushels (20 tons).

Pilot house, 10 feet by 12 feet 6 inches. It is 36 feet from bottom of hull to top of pilot house.

Pilot wheel, 6 feet at present; 8-foot wheel proposed.

Paddle wheel, 17 feet in diameter, 17 feet long; 14 buckets, spaced 3 feet 9 inches.

Shaft, 8.5 inches, hexagon; bearings, 7 31/32 by 9 inches.

Three balanced rudders, 15 feet 3 inches long.

Boilers—One battery, consisting of three cylindrical-type boilers 38.25 inches in diameter, 25 feet 7 inches long, having two flues each 12.5 inches in diameter, each boiler having a heating surface of 337 square feet—a total of 1011 square feet. These boilers are equipped with "Elesco" superheater, having a heating surface of 249 square feet, giving a total of 1260 square feet for boilers and superheater.

Doctor pump, or walking-beam engine, fitted with two vertical cold-water, single-acting plunger pumps.

Two 15-inch by 72-inch non-condensing engines with California cut-off valve motion.

One duplex fire pump.

One closed-type, feed-water heater.

One turbine generator unit, 7.5 kilowatts, 125 volts, direct current.

ANALYSES OF TEST

These tests were conducted between Guntersville, Ala., and Hobbs Island in both directions. The first test was made December 6, 1921, from Hobbs Island to Guntersville, which is up-stream. The following readings were taken at 30-minute intervals: Steam pressure at boiler and throttle; steam temperature at throttle; feed-water temperature entering and leaving heater; r.p.m. of engine; gas temperature at unit end and header end; draft, and CO^2. On this trip, departed from Hobbs Island at 1:20 p.m. and arrived at Guntersville at 4:20 p.m., consuming three hours to make run. Barge No. 5 was handled loaded with 10 cars having a total tonnage of 287 on barge. Traveling Fireman Neal fired on this trip until 4:00 p.m. and an average of the above readings follows: Steam pressure at boiler was 184 pounds; throttle 177.5. Temperature of steam was 612.5 degrees, or 234.2 degrees superheat; feed-water entering heater was 107.2 degrees, leaving was 200.6 degrees; r.p.m. of engine, 24.5; gas temperature at superheater unit end, 1416 degrees F.; draft in inches, 1.8, and carbon dioxid, 7.75 per cent. After Fireman Neal stopped firing and the regular fireman, Albert Henry, had been firing only 15 minutes the following readings were taken: Steam pressure at boiler, 165 pounds; throttle, 160 pounds. The steam temperature was 560 degrees, or 189.4 degrees actual superheat; feed-water entering heater was 96 degrees, leaving was 170 degrees; r.p.m. of engine, 20.5; gas temperature at superheater unit end, 1280 degrees F.; draft, 1.5 inches; and carbon dioxid dropped to 4.5 per cent.

LOGS OF RUN NO. 1

Time	Boiler	Throttle	Steam temperature	Feed-water In	Feed-water Out	R.p.m.	Gas temperature Unit end	Gas temperature Header end	Draft
1:17.....		170	580			24			
1:45.....	180	175	635	84	195	24	1400	800	1.75
2:15.....	180	175	630	115	210	26	1520	940	1.75
2:45.....	190	185	620	115	208	25	1380	1020	2.00
3:15.....	190	185	610	90	184	24.5	1310	910	1.75
3:45.....	180	175	600	132	206	24	1470	Note	1.75
Average	184.0	177.5	612.5	107.2	200.6	24.5	1416		1.80
4:15.....	165	160	560	96	170	20.5	1280		1.50

(Note—Reading of gas temperature at superheater header end was discontinued on account of having to open small clean-out door. This would cause a drop of 10 to 20 degrees in superheat, and a reading of gas temperature in breeching of smoke-stack was taken on all other runs.)

The second test was made on December 8 from Guntersville to Hobbs Island, down-stream. On this run, the same readings were taken as on Run No. 1, except gas temperature at header end of superheater. Instead of this, a reading was taken from breeching of smoke-stack, and in addition indicator cards were made in order to obtain the work done by engines and steam distribution. On this test we departed from Guntersville at 10:06 a.m. and arrived at Hobbs Island at 12:17 p.m., consuming 2 hours and 11 minutes. Albert Henry fired on this trip and the readings were as follows:

LOGS OF RUN NO. 2

Time	Steam boiler	Pressure throttle	Temperature: Steam at throttle	Temperature: Feed-water In	Temperature: Feed-water Out	R.p.m.	Gas temperature Unit end	Gas temperature Breeching	Gages of water	Draft
10:06.....	145	140	500	78	208				3	
10:15.....	155	150	560	76	206	20.5	1560	630	2.75	1.5
10:30.....	165	160	600	75	204	22	1580	580	2.75	1.4
10:45.....	160	155	600	67	200	24	1320	600	2.50	1.3
11:00.....	160	155	600	66	194	22.5	1310	560	2.50	1.3
11:15.....	160	155	590	66	196	22	1280	520	2.25	1.3
11:30.....	150	145	580	63	195	22	1380	570	2.25	1.3
11:45.....	160	155	580	73	205	22	1420	600	2	1.3
12:00.....	150	145	550	70	198	20	1540	520	2.50	1.2
Average..	156.1	151.1	573.3	70.4	200.6	21.9	1423.7	572.5	2.50	1.33

The average of actual superheat was 207.0 degrees.

On this trip nine barrels of coal were fired. One barrel weighed 367 pounds, thus the total fired was 3303 pounds, or 1.65 tons. The fire was raked 23 times and grates shaken 7 times.

Test No. 3 was made on December 8, from Hobbs Island to Guntersville, up-stream. The same records were taken on this trip as on No. 2. On this test we departed from Hobbs Island at 2:11 p.m. and arrived at Guntersville

at 5:19 p.m., consuming 3 hours and 8 minutes. Traveling Fireman Neal fired this trip and the readings were as follows:

LOGS OF RUN NO. 3

Time	Steam boiler	Pressure throttle	Temperature: Steam at throttle	Temperature: Feed-water In	Temperature: Feed-water Out	R.p.m.	Gas temperature: Unit end	Gas temperature: Breeching	Gages of water	Draft
2:15.....	170	165	550	82	217	25	1560	680	3	1.75
2:30.....	190	185	585	76	204	25	1640	620	3	1.75
2:45.....	195	190	600	78	208	26	1560	580	2.75	1.70
3:00.....	175	170	590	70	198	24	1280	540	2.50	1.60
3:15.....	180	175	600	74	200	24	1630	640	2.75	1.50
3:30.....	180	175	605	74	200	23.5	1460	650	3	1.50
3:45.....	185	180	600	76	202	23	1500	600	3	1.60
4:00.....	180	175	600		202	22	1500	560	2.75	1.50
4:15.....	170	165	600		196	23.5	1500	600	3	1.50
4:30.....	180	175	605		202	23.5			3	1.75
4:45.....	185	180	610		204	24.5			2.75	1.75
5:00.....	185	180	615		200	23			3	
Average..	181.3	176.3	596.6	75.7	202.8	24	1514.4	607.8	2.875	1.72

The average of actual superheat was 218.8 degrees.

On this trip 14.5 barrels of coal were fired, or 2.66 tons. The fire was raked three times and grates shaken three times. Pop was raised at 195 pounds boiler pressure, and pressure dropped to 175 pounds before it seated, and then it was necessary to jar the pop valve.

RATE OF COMBUSTION OF FUEL

	Date 1921	Total fired pounds	Fuel per hour: Running time, lbs.	Fuel per hour: Per square foot grate area, lbs.	Fuel per hour: Per square foot heating surface	Ratio coal to water
Down-stream	12-8	3303	1512.8	27.44	1.56	6.67
Up-stream.....	12-8	5321	1698.2	30.80	1.75	6.89

The total water used down-stream was 22,049.28 pounds, or 10,098.9 pounds per hour, showing that the evaporation was 6.67 pounds of water per pound of coal, or 8.015 pounds of water per square foot of heating surface per hour. The total water used up-stream was 36,646.72 pounds, or 12,215.57 pounds per hour, showing that the evaporation was 6.89 pounds of water per pound of coal, or 9.694 pounds of water per square foot of heating surface.

Indicator cards were made on each engine at first to study valve movement and steam distribution. No changes were made on the starboard engine, and this engine was found to be in good condition as to the steam distribution, with the exception of the admission on the head end, which was a little late, but not enough to cause any alterations to be made, since, the boat being new, it was necessary to get all working parts worn to a good bearing before making final adjustments.

The valves were out a small amount on the port engine. By the valves not having the same opening, one end of the cylinder was doing more work than the other. This was corrected and good steam distribution was obtained.

The total indicated horse-power developed from the test on this boat was 454.86 at a speed of 25 r.p.m. and steam pressure of 180 pounds. A speed of 26 r.p.m. was made for short intervals and an average speed of 24.5 revolutions can be maintained with full boiler pressure when handling one loaded barge.

RESULTS

In general, the results show that the steamer *Huntsville* is 40 to 45 per cent. more economical in fuel consumption than the steamer *Guntersville,* as during December, 1921, the *Guntersville* averaged burning 8.9 tons of coal a day, against 4.3 tons, or say 5 tons, a day for the steamer *Huntsville.*

This saving was effected by the application of the superheater and feed-water heater. The superheater increased the temperature of the steam at the engines 210 to 230 degrees, and feed-water was delivered to the boilers at a temperature of 208 degrees.

Office of Mechanical Engineer,
Nashville, Chattanooga & St. Louis Railway,
Nashville, Tenn. Jan. 19, 1922.

Mr. T. B. Sturges:* We have been hearing about some of the things engineers are doing to help transportation. There is one thing in which I think we have failed to go far enough. Every time we have a meeting of Congress, the Rivers and Harbors Bill is considered one of the biggest pork-barrel bills. I wish we would go far enough to help the public to understand these things. If we can understand how it is going to be a help not only to Pittsburgh but also to the people in general, we ought to have some way to tell the people. I wish an article like this could be put before the people of the United States in some publication like the *Saturday Evening Post,* so that people who pay the taxes, who are not directly benefited, may see the benefits that may come through river transportation and things of that kind. Engineers are the ones who understand these benefits, and we ought to have some way to get the facts before the public, and then we will have no trouble in getting appropriations.

Mr. A. E. Crockett: Relative to the matter of publicity, I quite agree about the necessity, as it is one of the great agencies for giving the public definite knowledge of national necessities.

*President, Pennsylvania Drilling Co., Pittsburgh.

There has been, during the past year, considerable effort, both through the press and addresses, to acquaint the public with the possibilities of transportation through the use of our inland waterways.

Mr. J. S. Martin:* The question has been raised as to why the construction of towboats for our rivers has not improved faster than it has. One very important reason is the opposition of the river men to such improvement. Progress in almost any line has been hindered by the fact that men who have grown up in the service with older methods were the men put in charge of developing the new. Two examples of this may be cited.

When the railroads were first started it was supposed that sea captains were the proper men to be in charge of them. It is said to be an actual fact that in a book of instructions to engine drivers, issued by one of these sea captains, he instructed the drivers that in case one of the stone blocks which were used as foundations for the rails had been left lying loose, too close to the track (or "line," as they then called it) by careless workmen, the engine driver was to put his train over on the opposite rail as far as possible, to avoid striking the block and wrecking the train.

Another example is that of the introduction of steam navigation on the ocean. Sailing masters were put in charge of the installation of the United States Navy. One young engineer, whose name I can't recall, who had enlisted in the Navy, was reprimanded for disrespect to his superiors, because he told them that two 3½-inch pipes would not carry as much steam as one seven-inch pipe.

In the same way, when the construction of river towboats was changed from wood to steel, the same men who had built the wooden boats were allowed to design the steel boats. These boats up to about fifteen years ago were merely boats in which steel had been substituted for wood. No attempt was made to use the steel girder properly, and the whole design appeared ridiculous to a structural engineer. When it was suggested to the river men that with steel it would not be necessary to build the boats so high, they considered it almost sacrilegious for any one to suggest that any improvement could be made, especially any improvement which would make it unnecessary to raise the Allegheny River bridges.

*Structural Engineer, Philadelphia Co., Pittsburgh.

Improvement is coming, and I believe that the next ten or fifteen years will see great changes in the construction of towboats. Two new types have been tested, but I have not heard what the general results have been. One is a boat run by screw propellers, working in tunnels on the under side of the hull. The bottoms of these propellers were placed above the bottom of the hull, so as to clear the bottom of the river wherever the boat could float. The suction of the propellers would fill the tunnels with water, so that the propellers were working in a solid column of water, even if they were above the water line. Preliminary tests were very favorable, but I notice that the type does not seem to have come into general use.

Another type was using steam turbines connected to the paddle-wheel by chains and sprockets, but I have not seen an account of any tests. Possibly some one can inform us as to the success or failure of that type.

Mr. A. E. Crockett: The Warrior River boats on the Mississippi are screw-tunnel boats at the present time. What their efficiency is I am not prepared to state, but a captain to whom I talked in St. Louis said he could beat any stern wheeler that went up and down the Mississippi River.

Mr. Howard L. Beach:* About a year ago last June I had the pleasure of a river trip on the Carnegie Steel Company steamer *Homer Williams,* from Pittsburgh to Aliquippa and return, in connection with an excursion of the Pittsburgh Post of the Society of American Military Engineers. On the trip a discussion of boat construction with Mr. William Whigham, of the Carnegie Steel Company, brought out some points which may be of interest here.

As to boats with paddle-wheels versus propeller drive, where the propeller is carried in a sort of well at the stern of the boat, the information was to the effect that this type of boat worked very well, provided it could be kept going straight ahead, and it would undoubtedly be very satisfactory where the barges were being towed with a hawser instead of being pushed from behind, as is the practice on the local rivers. In the latter case, steering of the tow around bends in the river is accomplished not only by means of the rudders of the towboat, but by manipulating the power machinery (propeller or paddle-

*Charles H. Clark & Howard L. Beach, Engineers, Pittsburgh.

wheel), and it is frequently necessary to reverse this machinery—in other words, back up—so as to swing the tow successfully around the bend. In this action it is found that the propeller boat does not seem to have the grip on the water that the paddle-wheel steamer has.

Another thing to be considered is that floating debris is easily sucked up, and this may seriously damage the propeller. If a screen is placed over the propeller to protect it, then the debris becomes clogged on the screen, materially affecting the efficiency of the device. There are one or two of these boats in use in the local harbor, and, from the conversation, I gathered that they are not found as efficient as the paddle-wheel boat.

In discussing the structure of the paddle-wheels, inquiry was made as to why the wheels were made of wood with straight blades and if there was any reason why the feathering type of blade as used on the Hudson River steamers would not be more efficient, since the straight blade has a tendency to lift water as it comes out of the water at the rear of the boat, as well as pound it on the downward stroke. The answers indicated that the facility for repairing the wooden-bladed paddle was the principal reason for its use, since the blades are frequently broken by river debris and accidental backing into obstructions, and that it was a very simple matter to replace a wooden plank which would break under the impact, while the metal blades of the other type of wheel would be dented and bent, pulling the wheel out of line and requiring considerable time and expense for repairs. This sounds very plausible, but the writer was not thoroughly convinced that the feathering wheel could not be worked to decided advantage over the straight blade. There are fewer blades required in the feathering wheel and I see no reason why these could not be made of wood, thus maintaining facility of replacement.

An examination of the *Homer Williams* was decidedly an eye-opener as to the advancement made in river steamer construction. The latest developments in engine design seem to have been incorporated throughout, the valve mechanism being of the Walschaert type, thus doing away with all eccentrics at the back end and reducing the danger of accident to a minimum.

Mr. N. F. Brown:* I do not think that I can add anything to what the speaker of the evening has demonstrated relative to this important subject.

Mr. Crockett has evidently given this subject considerable study, and, in answer to his question, "What is Pittsburgh doing to develop its harbors to keep pace with similar developments in other cities along the Ohio and Mississippi Rivers?" I would say that the recent heavy expenditures for terminal facilities on the rivers adjacent to Pittsburgh, now being constructed by some of the big industrial interests, are indicative of a change in the trend of the minds of those to whom transportation is becoming a serious problem.

I would recommend that each member of this Society procure a copy of the report—which I understand is now in the hands of the printer and will soon be ready for distribution—by the Waterways Committee of the Citizens Committee on City Plan of Pittsburgh. I had the pleasure of serving on this Committee the greater part of the past year. This is a very complete report, dealing with the preliminary and future development of the Pittsburgh harbors to accommodate water transportation and preserve the shore line for that purpose.

In conclusion, I would say that our Society is very fortunate in having as a member so forcible a speaker and one so thoroughly familiar with the water transportation problem. It is a pleasure to have heard Mr. Crockett, and his discourse on this subject is very timely.

*Brown & Reppert, Inc., Pittsburgh.

THE DEPOSIT OF DOUBLE-THICK UPPER FREEPORT COAL SITUATED IN THE VALLEY OF THE ALLEGHENY RIVER IN ALLEGHENY, BUTLER AND WESTMORELAND COUNTIES, PENNSYLVANIA*

By J. M. Rayburn†

This deposit lies in Allegheny, Butler and Westmoreland Counties, the long axis being in a northwest and southeast direction from the Allegheny River at the mouth of Pucketa‡ Creek. The length of the field on this line is 18 miles; about 11 miles northwest and seven miles southeast from the river. The width of the field at the river is seven miles, which might, roughly, be called an average width. The area is about 115 square miles, or 73,600 acres.

On the north side of the river the field is drained by Big Deer Creek, Little Deer Creek and Pine Creek, together with their many tributaries, and by smaller streams flowing directly into the river. The portion of the field lying south of the river is drained by Pucketa Creek and Plum Creek, with their tributaries.

The outcrop of this double-thick deposit occurs on both sides of the river for short distances. On the north side the thick coal comes in about Peterson station on the West Penn Railroad and goes under drainage at the mouth of Crawford's Run, about 7000 feet down the river. On the south side of the river the thick deposit comes in a short distance east of the No. 1 mine of the Valley Camp Coal Company and goes under drainage near the Valley Camp station on the Allegheny Division of the Pennsylvania Railroad. There is also an outcrop of a few hundred feet in length near Culmerville on the Bessemer and Lake Erie Railroad. The extent of the deposit is thus so completely concealed that the information to determine the extent and quality of the coal has taken an unusual amount of time and large expenditures for diamond drilling.

The proving up of this field has largely been accomplished by the enthusiasm and persistence of the late Selwyn M. Taylor, E. W.

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†Civil and Mining Engineer, Pittsburgh.

‡This is the spelling sanctioned by the United States Geographic Board in its fifth report, 1890 to 1920. In earlier publications and on old maps the name appears in various forms; for example, Paucatoes, Pocatoes, Poketo, Pucketos, and Pucketta.

Eisler, E. M. and F. S. Love, and A. B. Coleman, all of whom spent large sums in prospect work.

This coal was first mined and used commercially near the mouth of Bailie's Run for boiling salt, where the Bailies had salt wells drilled by the spring-pole method to a brackish deposit probably in the conglomerate at the base of the carboniferous formation. This salt plant was operating about 1830, and a small amount of coal was mined. The old pit mouth and some of the workings are still standing. About the same time this coal was mined for a like purpose at another saltworks near the present site of the Pittsburgh Plate Glass Company's mine east of Creighton station. Subsequent to this time, between 1850 and 1860, P. Y. Hite operated a mine below the mouth of Bailie's Run, and shipped coal on the Pennsylvania Canal, and later on the West Penn Railroad.

Some time near 1860 a shaft was sunk on the south side of the river at the mouth of Black's Run, a depth of approximately one hundred feet. The history of this operation and the reason for its abandonment are lost, but the depression showing the shaft location still remains, together with the brick stack of the power-house. The appearance of the earth about the old opening would suggest that the shaft has been on fire. At approximately the same time, a shaft was sunk on the north side of the river, below Hulton Ferry, three-fifths of a mile below Harmarville, but no coal was found, and it was abandoned. Subsequent to these early attempts at coal mining, P. W. Kountz sunk a shaft on Deer Creek, near Harmarville, and mined coal for a brick plant that operated a long time. About 1896 a shaft was sunk on Plum Creek, near Milltown, but was abandoned. It was reputed to have been unsatisfactory for mining.

During many years the only really active operation of any great capacity was the one at the mouth of Bailie's Run, owned by the Aetna & Vesuvius Coal Company, and operated by McFetridge Brothers on a lease. The most of this coal went at that time to the Spang, Chalfant Company, of Etna, and to Moorehead Brothers, of Sharpsburg, for steam and puddling purposes. It might be of interest to know that the leasehold rate at this mine was 12.5 cents a ton.

The actual beginning of development in the field might be said to have occurred about 1900, when the late Selwyn M. Taylor became interested in the exploitation of this coal. In 1901 he designed

and built the plant near Cheswick, known as the Harwick mine of the Allegheny Coal Company, a Cleveland concern. At the same time he acquired for his own interest that portion of the field lying on the waters of Deer Creek, where, in 1903, he constructed a hoist and air-shaft. He was going forward with the completion of this project at the time of his death, which occurred while directing the rescue work the day of the Harwick mine explosion, January 25, 1904.

During the year 1903 the shaft at what is now Russellton was being opened up, afterwards known as the No. 1 mine of the Bessemer Coal and Coke Company.

Since that time the field has been thoroughly prospected, its boundaries determined, and to a great extent it has been sold in large tracts to corporations for many diversified uses, but chiefly for steam and by-product purposes.

The Ford Collieries Company has three large shaft mines, the coal going for steam and by-product purposes; the Superior Fuel Company, one shaft mine, the coal going for fuel purposes; the Republic Collieries Company, two large shaft mines, the coal going for steam and by-product purposes; the Monarch Fuel Company, a new shaft mine; the Inland Collieries Company, one large shaft mine, the coal going for by-product purposes; the Consumers Mining Company, one large shaft mine, the coal going by river for by-product purposes; the Harwick Coal and Coke Company, one large shaft mine, the coal going to the Duquesne Light Company's power-plant at Colfax; the Allegheny-Pittsburgh Coal Company, one large shaft mine, the coal going to the West Penn Power Company's power-plant at Springdale; the Crucible Fuel Company, a slope mine, the coal going by river to the Crucible Steel Company for by-product purposes; the McFetridge Brothers Coal Company, a drift mine at Creighton, the coal going for steam and domestic purposes; the Pittsburgh Plate Glass Company, one drift mine, the coal going for general purposes; the Valley Camp Coal Company, two slope mines, the coal going chiefly for railroad fuel; the Diamond Coal Company, a shaft mine at Barking, the coal going chiefly for by-product purposes; the Newfield By-Product Coal Company, a shaft mine at North Bessemer, the coal going chiefly for railroad fuel; and the Union Collieries Company, a shaft mine at Renton, the coal being sold on the market for all purposes.

It is peculiar to this field that it was, and is, difficult to get Pittsburgh capital interested in any way, and as a result nearly all the plants are owned by companies outside of this district, and the coal, when mined, is used outside of Allegheny County. It might almost be said that the only benefit accruing to the Pittsburgh district from this deposit of coal is through the power developed by using this coal at the Springdale plant of the West Penn Power Company and the Colfax plant of the Duquesne Light Company.

The topographical conditions in this field are such that unusual facilities for the use and transportation of this coal are available. The Allegheny River gives 16 miles of slack-water frontage for river shipment and ideal locations for huge plants for the generation of electric power at the place of origin of the fuel; the Allegheny Division of the Pennsylvania Railroad is on the south side of the river, with branches on Plum Creek and Pucketa Creek; the Conemaugh Division of the same railroad is on the north side, with short branches to several operations; the Bessemer and Lake Erie Railroad traverses the field in a generally north and south direction for 14 miles, crossing Plum Creek south of the river, and being located on Little Deer Creek north of the river, with connections into the valley of Plum Creek and the valley of Big Deer Creek; the Baltimore & Ohio Railroad, which is in the valley of Pine Creek, also crosses the extreme western extensions of the deposit.

The average thickness of the normal double-thick coal is seven feet two inches, made up as follows: Beginning at the bottom, which is fire-clay, the section is three inches of coal, one inch of fire-clay, three inches of coal, one inch of fire-clay, 36 inches of coal, eight inches of high-ash coal, and 34 inches of coal, with carbonaceous shale roof. In some places this roof becomes an inferior cannel coal, as much as 18 inches thick, while at other points the roof is a laminated sandy shale.

Over the entire field there is no very marked difference in the structure and bedding of the different sections of the vein. The bottom eight-inch section shows some variation; in places the lower clay band is absent and there are from six to eight inches of coal below a single slate band. The 36-inch section above the lower bands is much the best coal in the seam, and is columnar in character, cleaving in vertical fingers. The high-ash section is made up of alternate

layers of bony coal and almost pure coal, and is horizontally bedded. The upper bench is blocky, having well-defined cleavage cleats, and is cubical in form, but is not nearly so pure as the lower bench.

It is frequently asserted that this deposit is the result of the Upper and Lower Freeport coals coming together, but experience and investigations have shown that this is not the case. The portion of the vein below the high-ash section is the normal or natural Upper Freeport coal, and the upper bench has been deposited on it, due to some favorable condition for vegetable growth existing over this particular area.

Under the practice in this district, whereby the bottom slates and high-ash sections are discarded, the vein yields 5 feet 10 inches of clean coal, and the cubic contents of the field, expressed in tons, is arrived at by the following statement: $5.83 \times 1742 \times 73{,}600 = 747{,}481{,}600$ tons, in which 5.83 is the thickness of the coal; 1742 is tons per acre foot; and 73,600 is the number of acres in the field.

The high-ash section of the vein, locally known as "the bone," averages eight inches in thickness and is always discarded. This is really a high-ash fuel of considerable value, yielding over ten thousand B.t.u. to the cubic foot, with a very high fusion point of ash. The discarding of this portion of the vein means the enormous loss of 86,000,000 tons of fuel, after it has been mined and practically prepared for use.

The combination of the upper and lower benches makes a mixture physically suitable for coke making, either in beehive or by-product ovens; but, unless the mining is very carefully conducted, the ash content is too high to make 12 per cent. ash coke. The coal has also been found to be extremely rich in by-products, and it is believed that it will eventually be used for the manufacture of by-product metallurgical coke without the addition of low volatile coals, which is the present practice. However, it will be necessary to reduce the ash content by washing or some other method.

An analysis, typical of the field and made from a channel sample of the whole vein, with the bottom slates and the high-ash section of eight inches discarded, is as follows:

Moisture	0.84
Volatile matter	31.05
Fixed carbon	60.31
Ash	7.80
Sulphur	1.36
Phosphorus	0.011

B.t.u., 14,160.

Fusion point of ash, 2580 degrees F.

The following is an analysis of the eight-inch "high-ash" section, discarded in mining:

Moisture	0.91
Volatile matter	24.93
Fixed carbon	44.31
Ash	29.85
Sulphur	0.87

B.t.u., 10,730.

Fusion point of ash, 2535 degrees F.

The stratigraphic peculiarities of this deposit open up so vast a field for conjectural geology that a full discussion cannot be attempted within the compass of this paper; however, some of the salient features can be pointed out. The field as a whole has no well-defined anticlines or synclines and might be described as lumpy, but with no excessively steep grades. There are holes and domes, and troughs of short lengths, and no projection can be made to guarantee a fixed grade without grading entries.

The outstanding geological landmarks in this region are the Pittsburgh coal, the Crinoidal limestone, the Upper Freeport coal and the Lower Kittanning coal. The interval between the Pittsburgh coal and the Upper Freeport coal is 640 feet, with the Crinoidal limestone almost exactly in the middle, or 320 feet above the Upper Freeport coal. The Lower Kittanning coal is 168 feet below the Upper Freeport coal and is fairly persistent.

The Mahoning sandstone, always thought of as being intimately associated with the Upper Freeport coal, and usually forming the roof, is not present directly over this double-thick deposit, except where it seems to exert a sinister influence by replacing the whole or part of the vein. Over large areas the sandstone is absent, being replaced by a laminated sandy shale, with a strong carbonaceous

shale lying immediately over the coal, and where the sandstone is present in part there are usually 12 to 16 feet of shale over the coal. In fact, the Mahoning sandstone seems to be in lenses or troughs in this field, and does not assume its usual massiveness except on the east and northeast sides of the deposit, where the double thick changes to the normal Upper Freeport coal. On the other sides of the field, particularly on the west and southwest portions, the horizon of the Mahoning sandstone is replaced in many locations by a mixture made up of the broken parts of all the original formations, so that frequently the horizon of the Upper Freeport coal is completely lost, and no recognizable stratum is found until the Lower Freeport coal is reached. When this chaotic condition is found to replace the horizon of the Mahoning sandstone, it is notice to the experienced prospector that he has reached the limits of the deposit.

The terrific erosive force which has exerted this influence on certain sides of this field may have caused some of the wants or so-called faults that occur with considerable frequency all over the field. These wants are all roughly oval in shape, and do not show evidence of the erosion of the coal by drainage, since the coal has its normal thickness on all sides of the want, and there are no signs of the drainage cutting into the bottoms; indeed, the coal is very rarely completely absent. The longer and more extensive wants resemble plough marks such as a glacier might make. There is also usually a deposit of several inches of fine clay shale immediately above the remaining coal, which indicates a very quiet period immediately after the removal of the coal. In all cases the replacement material above the clay is sandstone, being evidence that the removal of the coal occurred previous to the laying down of the Mahoning sandstone. However, as noted before, there is evidence along the boundaries of the deposit that the sandstone and the formations above it were destroyed as well as the coal. Some of the smaller wants are only a few feet in diameter and invariably, as they are approached, the bottom dips in all directions to the center of the want where the coal is sometimes totally absent.

To the person familiar with swamps as they exist to-day, where small open-water areas are frequently found, it might occur that on account of an excessive depth of water the vegetable matter of which the coal is formed could not grow. This fact of depth of water is

the usual cause of open water in present-day swamps, where the drainage current is absent or very slight.

The following maps and drawings are submitted herewith:

A map of this district showing streams, principal towns, railroads, and political subdivisions, on which the boundary line of the double-thick coal deposit is shown by a heavy dotted line (Fig. 1).

A section of the field on a northwest and southeast line through Russellton on the Bessemer and Lake Erie Railroad, which shows a profile of the surface topography and the bedding of the coal (Fig. 2, folding plate); also a cross-section through Russellton (Fig. 3) and one through New Texas (Fig. 4), showing the same details.

An actual section of a want developed in one of the mines, showing all details of the coal and replacement materials (Fig. 5).

Sections of diamond-drill holes; one showing normal conditions with the coal in place, and the other showing the disturbed condition of the formations with the coal absent (Fig. 6).

Fig. 1. Area of Thick Upper Freeport Coal.

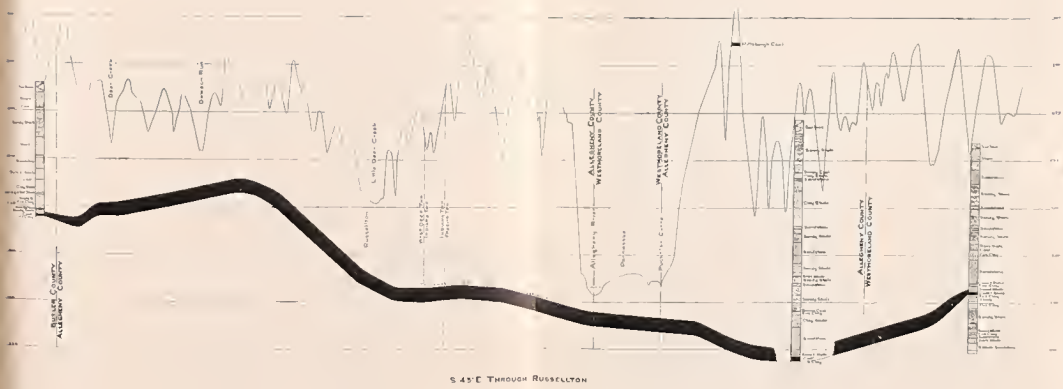

Fig. 2 Section of Thick Upper Freeport Coal Vein

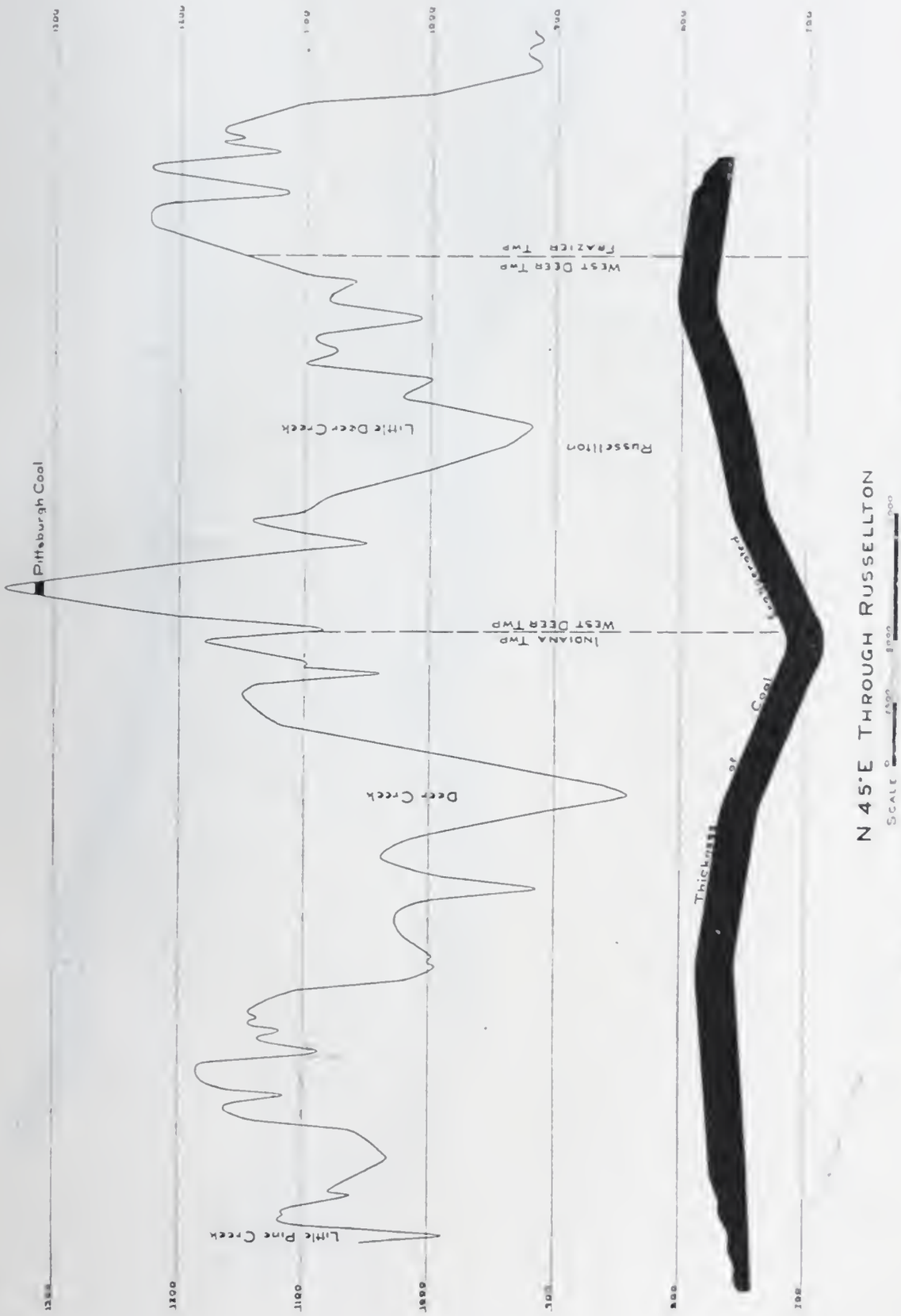

Fig. 3. Section of Thick Upper Freeport Coal Vein.

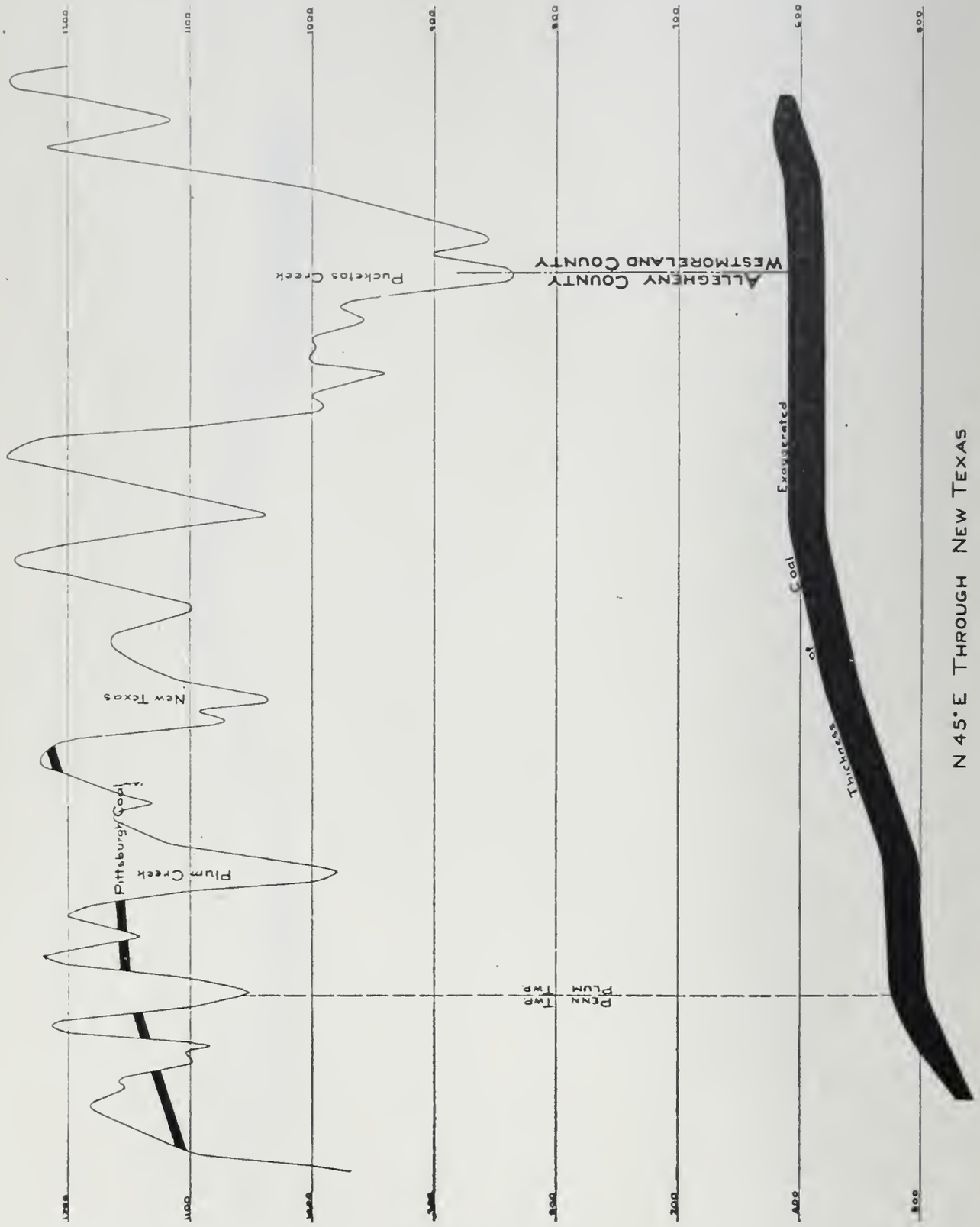

Fig. 4. Section of Thick Upper Freeport Coal Vein.

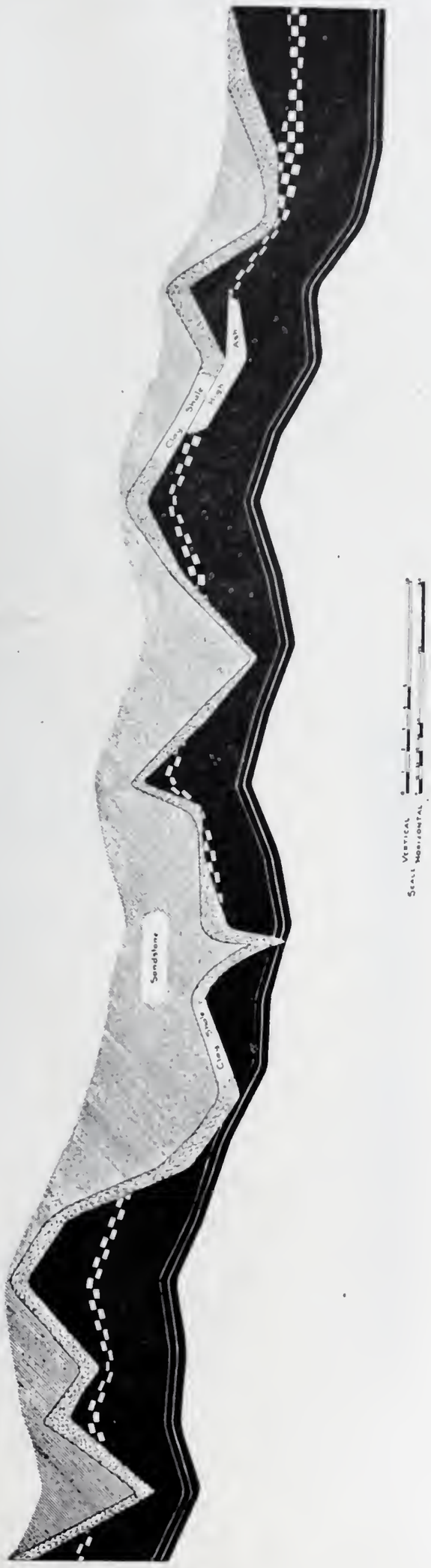

Fig. 5. Section of Fault.

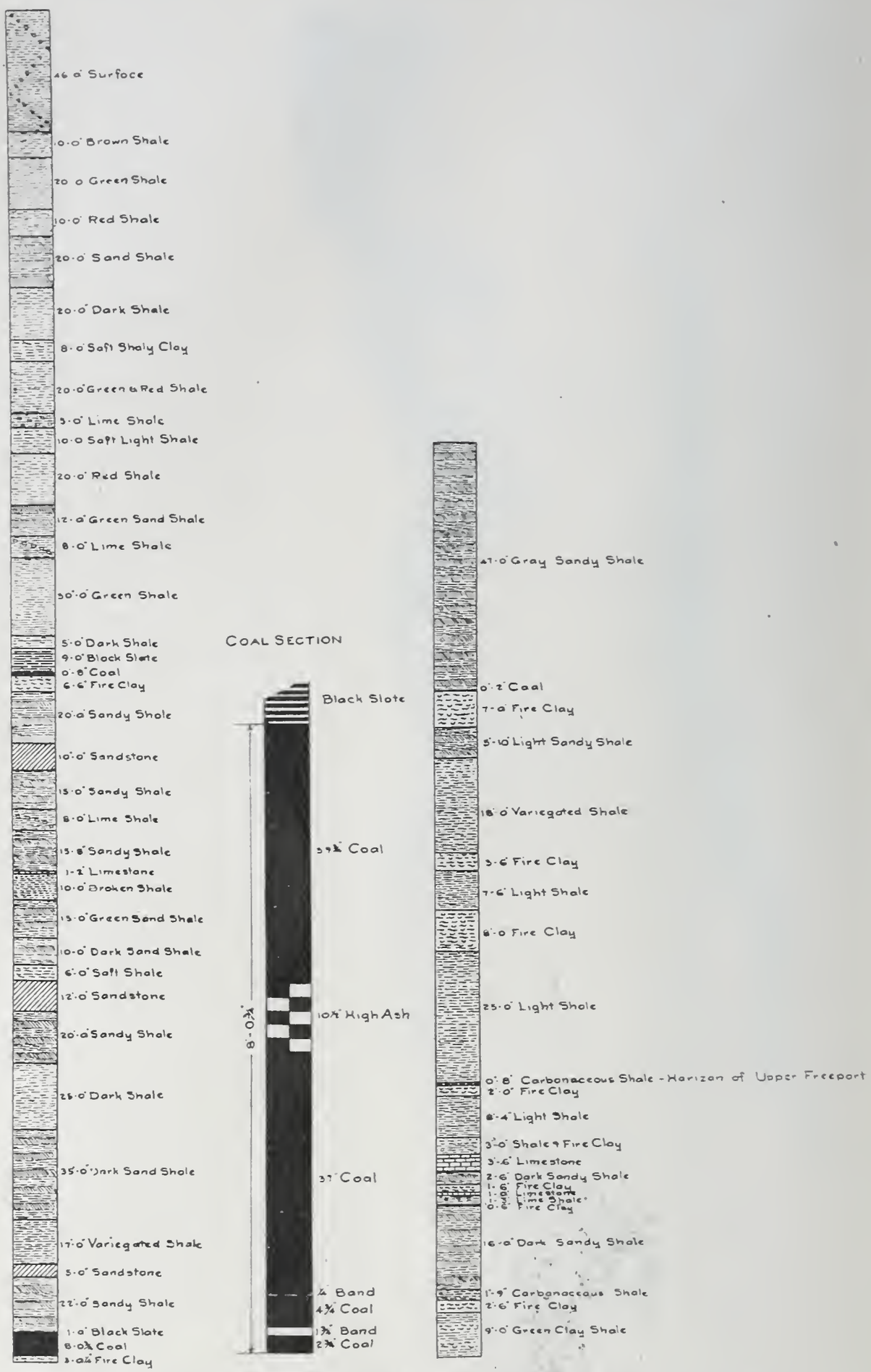

Fig. 6. Sections Showing Normal Conditions (at Left) and Disturbed Conditions (at Right).

DISCUSSION

Mr. Max Hecht:* Have any of the operators made use of the high-ash coal, or been able to dispose of it in any way? If they have, has the coal had any particular preparation for use?

Mr. J. M. Rayburn: The high-ash section was burned by the Bessemer Coal Company for a number of years at their No. 1 mine. I believe they crushed it. And the Ford Collieries burned it with stokers in their No. 3 plant a number of years, but I do not think they were very successful. They were possibly short of boiler capacity and could not crowd it. Those are the only places I know of where they have tried it. It was not very finely crushed—only to what you would call nut size.

Dr. Reinhardt Thiessen:† I have learned a good deal about the thick Freeport coal bed this evening. A good deal more may be said about it, however, in other respects. I do not quite like the term "double-thick Freeport." There is no such a thing as a double-thick bed. It is a single bed slightly thicker in this region than elsewhere. In studying the characteristics of the coal of the bed, and the general character of the coal as a whole, three specific characteristic spores are found. One of these is found from the bottom to the top. Another begins about halfway up in the so-called lower bench and persists clear up to the top; while another one begins in the middle of the upper bench and persists up to the top, including the cannel coal. The bone coal is not separable by a sharp dividing line. The coal gradually becomes bony and gradually turns into normal coal again. The kind of constituents in the bone coal are the same as in other parts of the coal, but the presence of larger amounts of mineral matter in the bone coal have in some way changed the nature of the organic constituents.

Taking the bed as a whole, the bottom part is very anthraxylous —that is, it consists largely of matter derived from larger parts of woody matter. In going from the bottom to the top, the coal gradually becomes less anthraxylous and more and more attritious, and

*Chemist, Duquesne Light Co., Pittsburgh.

†Associate Research Chemist, Pittsburgh Experiment Station, U. S. Bureau of Mines.

gradually approaches the nature of a cannel coal, until the top of the upper bench, where it turns sharply into true cannel coal.

The coal becomes richer and richer in spore matter from the bottom up, parallel with the increase in attritious matter. As far as I have been able to find, the whole thick Freeport area is overlain by cannel coal, varying in thickness from a fraction of an inch to 33 inches. The cannel coal is relatively low in mineral matter in the lower part, but gains gradually in mineral matter until the middle, then gains rapidly in mineral matter, and finally turns into shale.

The bone coal is apparently formed through the addition of silt to the ordinary coal-forming matter. Some disturbing condition occurred in the geologic history. Just what the exact cause of the additional mineral matter was is hard to say. It may simply be silt. I have always held that volcanic ash was deposited over the earth's surface; such a deposit would get mixed into the plant debris in the deposit through a considerable thickness and thus account for its gradual appearance and gradual fading out. The volcanic-ash theory is being refuted by mineralogists on account of the nature of the mineral matter.

As to the reason of the gradual change from an anthraxylous coal to an attritious coal, I have this explanation. At the time of the deposition of the bed, the earth's crust in that region was gradually sinking. The bog began with a wooded swamp, and the matter deposited was very largely woody, giving rise to woody or anthraxylous coal. The swamp gradually became wetter and wetter, hydrophytic plants were gradually crowded out by aquatic plants, until finally nothing but aquatic plants remained, resulting in cannel coal. Water, too deep for plant growth, finally stood over the bog and shale was deposited.

The idea that the thick Freeport bed is the union of the Upper and Lower Freeport beds is untenable. After studying the conditions for only a little time, I readily came to that conclusion.

Lately we have studied the coal beds of the Allegheny formation in Ohio. In every case we found the Upper Freeport bed to have the same characteristics as in the thick Freeport region. The Mahoning sandstone appears in the same manner and is the cause of the same kind of "horsebacks" as in the region in question. Even the bone coal appears to some extent—that is, there is an indication of the bone coal.

In certain localities of Ohio, also, it is almost as thick as it is here. Now, why should you call it the double-thick bed? I should not call it double, because it is not double, but just thick. It is only a single Freeport bed.

MR. J. M. RAYBURN: Since 72 inches is double 36 inches, and the normal is 36 inches, it seems to me you are giving the best argument for the name I have given it.

DR. REINHARDT THIESSEN: We have found it 11 feet thick, without the shale on top. The Mahoning sandstone appears exactly the same way in Ohio as it does here, with the same "faults." The sides of the faults rise very steeply. I construe this to be erosion and deposition phenomena. There must have been a time after the bed was laid down, maybe many years later, when the overlying strata together with the coal were cut away by erosions, over which the Mahoning sandstone was then deposited. In studying the coal, one finds that the coal is actually cut out. The layers and striæ of the coal are cut off at this fault.

MR. J. M. RAYBURN: Where did the drainage go?

DR. REINHARDT THIESSEN: That I do not know; but the earth's crust had been bent before the advent of the Pittsburgh bed.

MR. J. M. RAYBURN: I think you misunderstood me. I suppose at the time this erosion occurred it was level, or practically so. You say an erosion, which means a drainage current.

DR. REINHARDT THIESSEN: Glacial.

MR. J. M. RAYBURN: In an experience of over thirty years in this field, I have never found a place where the drainage came in at the top of the vein and went out at the bottom. It has always been like a gouge. We have gone along many faults. Some of them are pretty nearly round and very deep, but the bottom drops. I have never found any evidence of drainage going out through the coal and out into the bottom.

DR. REINHARDT THIESSEN: The characteristics are exactly the same in Ohio as they are here; we are, therefore, able to distinguish between the Upper Freeport and the Middle Kittanning.

MR. W. E. FOHL:* Have you any explanation to suggest concerning the clay bands between the coal and the sandstone in this coal where the wants occur? I was in a mine to-day where there is just a thin layer of clay—possibly one-half inch—between the top of the coal which was eroded and the sandstone which replaced that erosion.

DR. REINHARDT THIESSEN: I don't believe I have.

MR. J. M. RAYBURN: It seems to me that is an evidence that subsequent to what happened to this coal it was quiet and allowed that sediment to settle there. It is almost like talcum. It seems to me that would dispose of any argument for erosion.

DR. REINHARDT THIESSEN: We have no knowledge as to how, exactly, the earth's crust was bent, except that there was a bending with an axis in a general direction running in a northeasterly direction; but whether any riffles or ring-shaped bends were formed I do not know. I do not think that geologists know. When one reads about things in the books they are described in a very definite way, but when one gets into the field, one finds that definiteness is not there, and one finds all sorts of variations, for which the geologists make no explanation.

MR. T. J. FEAR:† What percentage of this field is overlain with cannel coal?

MR. J. M. RAYBURN: I would say possibly 20 per cent. is carbonaceous shale and the rest is sandy shale roof, without any cannel coal at all.

MR. W. A. WELDIN:‡ These strata come out horizontally; they do not follow the bend. I saw that in Ohio. It is, no doubt,

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†Superintendent, Inland Collieries Co., Indianola, Pa.
‡Blum, Weldin & Co., Pittsburgh.

exceptional and may have been caused by formation of coal after the erosion. In one place particularly it was very plainly marked. In the Cambridge field the wants are very large, and I was told they occurred in a generally northeast and southwest direction. I put together the maps of adjacent mines to try to discover some system to the occurrence of want, but was unable to do so. In that field they are of every conceivable shape, size, and general direction. Sometimes the coal thickens near a want, sometimes it does not, but almost invariably the roof comes down just at the edge of the want. The character of the wants is exactly that so graphically illustrated by Mr. Rayburn.

Mr. J. M. Rayburn: I would say that, in this particular field, the faults show that the coal was laid down in its entirety before the fault occurred and the high-ash coal was formed in the proper place. I have seen some slight variation but, in general, every coal shows that it was laid down entirely before the erosion occurred, or whatever it was that happened.

Dr. Reinhardt Thiessen: The stripping mines are the best places to study coal beds, and one can there study variations more advantageously. In an Ohio stripping mine the superintendent pointed out to me a place where the bed suddenly arose to a thickness almost twice that elsewhere, and in a couple of rods along the cut it dropped as suddenly to normal. Can you explain that?

Mr. J. M. Rayburn: Within 60 feet the Freeport changes from single to double thick in the outcrop on the Allegheny River. You can see it at No. 1 mine of the Valley Camp Coal Company.

Mr. F. J. Fear: Does that appear in the field farther south?

Mr. J. M. Rayburn: It shows up again along the Baltimore & Ohio Railroad, but does not go very far.

Mr. F. J. Fear: How do you explain the thickening of the coal on either side of the want?

MR. J. M. RAYBURN: You are getting under my armor now. I do not know. That looks as though it might have been squeezed out.

MR. F. J. FEAR: There is just one thing. The want is just about a mile long. On drilling across both ways I found that the general direction of this want is almost parallel to this other and also parallel to a lot of clay veins on the eastern side of that. Mr. Rayburn was the first man we went to to explain that.

MR. F. K. HOWELL:* It might be timely to remind the members that this thick Freeport seam and the rest of the Upper Freeport seam that we have so thoroughly discussed represent a storehouse of gas coal that, some time in the future when our natural-gas supplies decline, will be very valuable as a source of artificial gas in this community. I do not mean by this to imply that natural gas is going to be gone in a few years, but this coal will undoubtedly be the most important kind gasified in the large artificial gas plant or plants which will eventually be constructed to take the place of our natural-gas supply.

MR. J. M. RAYBURN: The trouble is that it was not realized soon enough. Gas companies are not interested in this particular district. It's gone.

MR. F. K. HOWELL: How about the Upper Freeport; is that all taken up, too?

MR. J. M. RAYBURN: I think it is.

DR. REINHARDT THIESSEN: Has the territory in the southwestern part of Pennsylvania, covering Washington, Greene and Fayette Counties, been drilled for the Upper Freeport coal?

MR. J. M. RAYBURN: No, not thoroughly.

DR. REINHARDT THIESSEN: I imagine that that is all underlain by the Freeport bed. There are thousands of acres of land where it was supposed that no coal existed, but it is there.

*Superintendent, Compressing Stations, Equitable Gas Co., Pittsburgh.

THE RELATION OF THE ENGINEERING DEPARTMENT TO THE OPERATING DEPARTMENT*

By F. J. Croliusf

The above subject is one which assumes much; which causes much speculation; but about which it is very difficult to secure concrete unanimity of opinion.

A great deal depends upon the point of view; a great deal depends upon the particular organization under discussion; but more depends upon the personalities involved in the relationships. The subject may first be viewed from its many angles, and perhaps a distant perspective may disclose the true relationship.

First, let us look at the mental attitude, the psychological aspect of each side, for it is definitely two sided.

The officials of operating and producing departments are, and must be, first, last and always, result getters, producers, profit makers; they are practical men, or at least are supposed to be; they feel that no one else is quite so familiar with their own detail daily problems as they themselves are; they feel that they are held solely responsible for the continued success of their individual business—for in the last analysis each department is a business—and, being solely responsible, each resists any and all outside interference, particularly by men—close friends though they may be—not versed in all the petty detail which clutters up the time of the average operating or producing department manager. The underlying thought—sometimes unspoken, occasionally outspoken—is: You have your own work to keep you busy. You have plenty to do and so have I. Run your own department and I'll run mine. When I want suggestions or ideas I'll ask for them.

This may sound very offensive to sensitive ears, but it is merely a common expression.

The operating and producing departments want progress, but want that progress without disturbance of a present condition of static comfort, order, and method; for change, even in the smallest routine matters, means change in existing relationships between present operatives; means change in functional activities; means change in mental processes.

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†Editor, Blast Furnace and Steel Plant, Pittsburgh.

As long as there is a fair balance in comparisons between present results and past performances under like conditions, no change is desired. It is only when competition or stringency or some emergency demands a revision of existing practice that the operating or producing departments acknowledge that changes are necessary. The viewpoint is personal.

On the other hand, the engineering department thrives on changes. Its business is drawing, and scheming and planning; ever investigating, making comparisons, weighing results of experimentation, adding, deducting, calculating, pitting the slide-rule against the rules of practical experience, tearing down on paper and rebuilding again, ever seeking. The engineer's training is such that his mind is seldom fettered by the routine of a limited number of tons, or heats, or men, or hours per day; he thinks, or should think, in terms of impersonal progress. He is a business man of quite another sort, interested in present conditions only in terms of future possibilities.

It is not to be wondered at that such psychological opposites should little understand each other and should with difficulty find common ground upon which to walk in rhythm.

It was my good fortune to be intrusted with the organization of a combustion committee in a very large grouping of blast-furnaces, steel-mills and power-houses. That sounds like a simple commission.

To the committee meetings were invited all the producing superintendents. They came rather reluctantly, as most of them scarcely thought of combustion in terms of their own departments. Our first aim was to find out their ideas and knowledge of combustion applied to, or as affecting, their respective operations. It was agreed that each should submit a short thesis on each division of the subject as it affected him. There was but *one* thesis.

This may sound surprising, but it need not when analyzed. There were definite reasons why nothing was submitted:

1. Few men were in the slightest interested in the subject. They considered the matter of secondary importance.

2. Few knew anything in particular about this subject, which to them seemed foreign to their specialized operations. They felt that fuels, gas supply, tar, coal and power were merely necessary evils which had always taken care of themselves, and probably would continue to do so in the future.

3. Those few who did realize the importance of combustion to their successful production were probably too busy, or unable to summarize their knowledge in a report on the subject.

But the investigation thus far had shown several things:

1. That it was essential that a spirit of co-operation among all departments be developed.

2. That apparent local prejudices must be broken down.

3. That engineering data must be secured and correlated by the engineering department.

4. That these data must be interpreted in terms of each local department.

5. That each department head must be brought to realize his share of a joint responsibility.

All this was accomplished, and the results were startling. The open-hearth department became convinced that combustion meant tonnage, and more tonnage meant reduced costs. The armor department found a solution for destructive corrosion of valves and fittings on its great heating furnaces. The rolling-mill departments learned the relations between soaking-pit and heating-furnace design and construction in terms of combustion, going so far into the subject as to question the location of strippers, and suggest changes. The mechanical departments became aware that line and valve repairs were entirely unrecorded and unsystematized. The fuel company found a new and convenient avenue for a far better distribution schedule.

I have mentioned combustion and have gone at some length into relating of incidents and results accomplished through co-ordinated engineering investigation. Let me touch upon another matter—centrifugal force. Centrifugal force is an accepted application in many mechanical combinations, but its possibilities are but remotely known and understood in the steel industry. Centrifugal force can be developed usefully in many ways. Two simple methods are well known—one, rotating elements, such as fan motors, or pump impellers; the other, the swirling of gases, steam, water, or air, through the medium of vane structures. Many separators, traps, etc., employ this force in greater or less degree. You may inquire just what this particular force has to do with the relation between engineering and operating. It has much to do with it. So many practical problems find their solution in the proper application of centrifugal force that

it is merely a question of the engineering department tying the solution to the particular problem, and then seeing that the operating departments put the solution into practice.

For instance, the handling and use of blast-furnace gas presents many problems of considerable magnitude. The gas must be cleaned, and must be burned, either in stoves, under boilers, or in gas-engines. The recovered dust must be prepared for rehandling into the blast-furnace. The water used in and about a steel unit, a cooling system, or a power-house should be clarified, or filtered. Gases from by-product plants carry much moisture, and occasionally acid; this should be trapped out. Steam carries a large percentage of the solids which have been fed into the boiler. These solids and the moisture in outgoing steam, plus the condensations, demand serious consideration at the turbine or prime mover. Air when compressed contains much moisture which should be eliminated. Fuels when burned require definite supplies of air for combustion and intimate mixing at high velocities for good ignition. Solid fuels when burned deposit much ash beyond the furnace proper, causing many complications in boiler settings, in heating furnaces, in open-hearth furnaces, and often, in the case of pulverized-fuel units, much complaint from surrounding communities.

Casual thought will lead to the conclusion that the enumerated operations and many others possess one or two characteristics in common; either they involve the function of intimate mixing, or of careful separating.

Centrifugal force is the most fundamental method for mixing or separation. In the discussion of engineering and operating relations, there could be no more fruitful field of research than the discovery by the operating organizations that so many of their difficulties come within the possible scope of a centrifugal solution, and then putting it up to the engineering department to work out the solution.

To secure more than a personal and perhaps local perspective, I have taken the opportunity of discussing this question of "relationship" with many men of different minds. Anonymously, we will quote the thoughts (1) of a well-known sales engineer, (2) of an American resident engineer in foreign operation:

1. In developing any engineering scheme in a steel plant, the ordinary attitude is:

a. The engineering staff is sufficiently informed upon every subject to make suggestions from any quarter unwelcome. It is unnecessary to employ any consultants.

b. The sales engineering staff, being in the very nature of things not so informed, proceeds to obtain *ex parte* statements from the salesmen of various manufacturing concerns. These are usually valuable in the inverse ratio of the plausibility of the statements made. The poorest staff has the sleekest salesman.

c. Meanwhile the engineers have been guessing at the amount necessary to be appropriated for the given work. In estimates made by many corporations, there seems to be a deliberate attempt to make the suggested appropriation far in excess of the amount actually needed on a crude "factor of safety" theory. This, of course, makes the money-granting power loath to grant the large sums (relatively considered) which are asked for, and thus unduly delays needed improvements.

Often the engineers make some radical error of calculation, and the appropriation, with all its factors of safety, is too low. The unfortunate contractor is then held down to a very cheap competitive figure and quality suffers; price governs, and chicanery is at a premium. The same sleek salesman who talked loud and long is again in evidence and likely enough walks off with the order. The salesmen for apparatus of this class are heard to remark that "one is born every minute." Engineers of national prominence are heard to remark that the handling of steel-plant engineering as conducted under average conditions is an economic crime.

Both are telling the truth. If steel-plant operators and engineers were as frank and truthful as they require salesmen to be when offering apparatus and material to their companies, there would be a great saving on all jobs constructed. The good would come to the front, because frankness and an able and honest contractor would help the steel-plant engineer to see where the leaks occur; but nobody can do this if he does not know the facts and all the facts. On the part of some engineers there seems to be an attempt to conceal these facts to the greatest extent possible and for the longest time possible. The only possible theory for this course seems to be that, as the company is likely to be "stuck" anyhow, the engineer will protect himself to the greatest possible extent.

2. Here we have a foreign viewpoint regarding the relation of the operating and engineering departments in the Indian steel industry.

Steel making in India is, at present, limited to the operations of one company. However, two other companies operating blast-furnaces may be included in these comments. The steel company is American in management and largely American so far as departmental supervision is concerned. The other two companies are under British management and partly under American supervision.

At the steel plant, *operation* is now, and always has been, dominant, regardless of the manner in which it was carried on or the results attained. The several department heads have been free to carry out their own ideas of construction and alteration, very largely as they wished, having only to secure the approval of the management, whose attainments were of a practical nature only.

The engineering department, being subordinated in importance to the operating departments, was usually consulted only when the heads of the latter thought they were insufficiently grounded theoretically in the problems under consideration or had not sufficient knowledge of interdepartmental production. The whole plan was based widely upon the assumption that the engineer was a kind of assistant to the master mechanic, who, of course, is purely an operation man.

At those plants under British management there is quite a different atmosphere as regards the importance of the engineer in plant operation, maintenance and expansion.

Apparently the condition at the plant under American management is nothing other than the result of the application of ideas prevalent here in the steel industry.

These specific applications have been mentioned because they suggest a way of making the discussion concrete rather than purely general, and because they present illustrations of the results which may be expected when operating departments and engineering departments work in complete harmony, with thorough understanding of the responsibilities of each. The viewpoints cited contribute evidence of the need of this closer co-operation.

We speak lightly of these divergent organizations—the operating on one hand, the engineering on the other. Would it not be well to

define them both, in our own minds at least, as we inquire into their functions and inherent characteristics? Each is charged with definite jurisdictions; each has certain points of strength; all have recognized points of weakness.

Operating departments are primarily held responsible for production; it is their duty to keep mills running, to produce competitively, in spite of any and all interferences or difficulties. It matters not whether a labor shortage exists, or a car shortage, or a coal shortage, a drought, a heat wave or zero weather—as long as there are orders on the books, those orders must be filled and shipments made on time. And to the credit of the operating men, these things do get accomplished, some way, somehow—often it seems that miracles have been wrought. This is because, primarily, the operating man is an executive, trained to use to the best advantage the forces, men, materials and equipment at his command. "Fail" is not in his dictionary. "Results" is a watchword. Unfortunately, constant scrutiny of immediate details paves the way for his greatest weakness. He has little time for observation, and has a tendency toward reaction. Innovations seldom interest him. He falls behind in his methods, his equipment becomes obsolete, his organization becomes unprogressive, and his costs rise.

At this point, the value of an engineering department manifests itself.

The engineering department should, primarily, be a fact-finding organization—an educational organization, if you will—at all times willing and prepared to point the way out of difficulties.

Unfortunately, many great organizations limit their engineering departments in too many ways and call upon the engineers for the wrong type of information.

Most engineering organizations are supposed to make drawings and tracings; they are charged with maintaining records of equipment, and changes made to old equipment; they are supposed to estimate new appropriations, request appropriations, to draw specifications, to place orders and contracts. Often the engineering department does some research work, or carries an experimental crew which makes tests and determines heat-balances, rolling costs, etc. Occasionally there is an efficiency engineer who does everything except produce better results more harmoniously. But these functions, important as

they all seem, are the least which a real engineering organization should accomplish.

The end and aim of every industry is to produce profits—profits accruing as the net result of the labor of contented workmen investing their time, their energy, their very lives in the operation of machinery best adapted to its purpose, under conditions which are conducive to health and happiness. It is the business of the engineering department to see that those aims are met.

It is the function of the engineering department to place in the hands of the operating departments such tools that they can successfully compete in the great contest for profits and contented workmen, for to-day and in the future workmen will gravitate to the points of greatest reward.

It is unnecessary to present concrete illustrations; all of you here present well understand the complexity of thoughts involved. Many of you are salesmen, or sales managers, who visit the various organizations. You call upon the purchasing agent, the mechanical engineer, the electrical engineer, the master mechanic, possibly the general superintendent, and even the president. You are surprised by an apparent lack of co-operation among themselves and with you, and by the evidences of most superficial knowledge of your own specialty which any one of the interested parties seems to have, and you wonder how they manage to run and prosper at all.

There are so many angles of viewpoint between the production of any article from the raw material, and the selection, design, and operation of the mechanical means to produce it, that no one of us can understand it.

May I offer this thought in closing: If we are to succeed, we must more and more call upon our engineering departments. There are few problems which engineering can not solve.

DISCUSSION

Mr. E. P. Dandridge, *Chairman*:* I am sure we have all listened with a great deal of interest to what Mr. Crolius has had to say. I know he touched on one or two points that were very near to me as a sales engineer. We should have a good discussion of the subject.

In dealing with various concerns, it has been my experience that the apparent lack of knowledge of what they want is one of the worst things we are up against. We go to operating departments with five or six competitors; we all present our ideas, and before the man gets to the point of deciding what he wants he is completely confused, and the usual result is that the company with the best salesman puts in its stuff, without regard to what was in the plant before or the plant's service experience. Also, in plants, there is a sad lack of standardization. In conveying machinery, which happens to be my particular line, assembling into a complete system a lot of miscellaneous parts, with absolutely no regard for standardization in anything, seems to be the custom. They put in any size anywhere, without any regard to what has gone into the plant before.

Another thing of which we engineers ought to take cognizance in discussing the relations between the engineering and operating departments is that the operating department almost always gets the credit. The engineering department may perfect wonderful advances in methods; but when they are put into effect and the operating cost goes down, the operating department gets the full credit.

Mr. E. Willis Whited:† I was just thinking about some of the troubles I had when I was starting up by-product coke plants. Frequently I found many blunders on the part of the engineers. Sometimes these were laughable from an operating viewpoint. However, when an engineer had explained it, the joke was often on the other side. What we need is more co-operation between the two. The engineers should talk over their new ideas with the operating men and get their viewpoints; similarly, the operator should keep the engineer advised of the results that are being secured. This exchange of ideas and results would go a long way towards reducing the friction—or, more charitably speaking, the jealousy—which exists be-

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tween the two departments. Another thing that must not be overlooked is the fact that the engineer usually has to work at high speed and is required to do all his work in a comparatively short time. He has small opportunity for checking his design in a large way. The operator, however, is not handicapped in this way and can take his time about finding the mistakes of the engineers. Many of his own mistakes are never discovered.

Mr. E. P. Dandridge: I had a rather startling illustration of the lack of standardization recently. For one of the biggest corporations my company bid on two equipments of exactly the same material, which, as far as I know, were both designed by the chief consulting engineer of the corporation. He decided one installation in favor of one type of equipment and the other in favor of another type. If one was right in one case it was right in the other, and if it was not right in one it could not be right in the other. I do not understand it. It was a corporation which you would expect to take a standard and stick to it. I think it was just a case of salesmanship—two different men selling the two things. A few years from now they will wake up and find one of them is wrong.

Mr. V. B. Edwards:* I have been an interested listener. The problems are everyday ones. Another phase of the matter that I have had might be of interest. You always have the production man or the operating man on his job keen to do his work, and the same way with the engineering department; but each of these fellows is too apt to leave a job before he has finished it. If the engineering department would follow through the jobs for which they are responsible, and clean up any kinks that turn up in the operating; and if the operating department would check up and be sure that the engineering department knew what had happened, it would contribute to the common good very materially. There is too little of that, and that is where our co-ordination falls down.

Mr. E. P. Dandridge: Do you think that is the fault of the engineering or the operating department? Is it not rather the fault of the head of the business?

*General Manager, Engineering Works Department, Dravo Contracting Co., Pittsburgh.

Mr. V. B. Edwards: It is to a certain extent.

Mr. E. P. Dandridge: When the engineer has finished his job he turns it over to the operating department, and the operating department gets credit for it anyway, so the engineer is just as well rid of it, in the majority of cases. Are there any engineers here who could, without getting themselves in hot water, tell us whether, in making their estimates, they play safe in the hope of getting away with it, or whether they figure closely in the hope of getting the work started? Some one was telling me recently that there are more worth-while projects killed by engineering estimates than by anything else in the world, because the estimates are made too high. That is a rather interesting phase of it—whether the engineers kill prospective improvements which the operating departments might want by making the estimates too high.

SELECTION OF SAND AND GRAVEL FOR CONCRETE IN THE PITTSBURGH DISTRICT*

By C. M. Reppert†

The period of the past twenty years has witnessed a great and constant increase in the quantity of Portland cement concrete placed annually and in the variety of its uses. The development of more accurate and dependable theories of design and the accumulation of working data have accompanied the increased use of concrete. Practice as regards adapting theory to specific problems, requirements, and conditions has at the same time passed through a process of development to conform with theory, and a process of adjustment to conditions and results as developed by field experience and laboratory work. The refinement of theory, the adoption of increased stresses used in many kinds of work (largely brought about by the use of reinforced concrete), together with increased loads imposed (as notably in highway work), call for a better class of construction to-day than was required in the past.

To-day, with theory well developed and with designs made on the assumption of high unit strength, and of satisfactory performance as to permanence and resistance to destructive agents, it is of great interest to engineers to determine the accuracy of the assumptions and to adapt practice to the assumed conditions upon which theory is based. The problems are largely those of a practical nature involving the selection of materials and the mixing, transportation, and placing of the concrete in such manner as to insure satisfactory results. In this connection it is generally recognized that it is unwise to adopt abstract data for specific problems, as it is becoming more and more realized that the strength and permanence of concrete depend to a very great extent on the local material used and the methods used in mixing and placing. Naturally, these factors vary with the locality, the character of the work, and the construction methods used. It is, therefore, of great importance that the physical characteristics of local materials be known and that the materials used conform to certain standards of suitability.

The greatly increased use of concrete and the increasing fund of

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†Brown & Reppert, Inc., Pittsburgh.

knowledge gained through the observance of its performance in service under various conditions—as in its ability to withstand repeated and continued loads and to resist destructive agents such as water, atmospheric impurities, freezing and thawing, etc.—have brought to the attention of engineers the necessity for the exercise of greater care in the selection of materials, in the proportioning of the mixture, and the methods of making and handling the concrete. It is also to be noted that there has been a gradual change in opinion as to the relative importance of certain of the factors affecting its strength and permanence (for instance, the water ratio), and it is also recognized that there are certain problems with regard to concrete which are worthy of further study and investigation. This is evidenced by the discussions which took place at the latest meeting of the American Society for Testing Materials at Atlantic City, where many of the problems were defined and discussed; and also by the current discussion of a paper by William G. Atwood and A. A. Johnson in the *Proceedings* of the American Society of Civil Engineers, August to December, 1923.* The publications of the two societies mentioned constitute extremely valuable contributions to our knowledge of concrete, as they approach the subject from the most satisfactory angle—that is, from the results of experience.

Ordinary concrete is composed of variable materials mixed together in presumably definite proportions—which in actual practice are generally variable—and transported, placed, and worked in a series of operations each of which has an important effect on the finished product.

This paper, which is primarily devoted to the selection of sand and gravel for concrete, is offered not as a solution of the problem of selection, but rather to present to this Society such information as was gained as to the local materials and the measures taken to improve the quality of concrete by the Bureau of Engineering, Department of Public Works, of the City of Pittsburgh, during 1921-1922, when the author served as Chief Engineer. Certain investigations of materials; of existing specifications and practices; and inspections of new and old concrete were then made; new requirements, both for materials and for concrete itself, were put into force and a system of control, sampling, testing and recording put into effect. The writer

*V. 49, pp. 1038-1064. Discussion, pp. 1647-1661, 1762-1766, 1914-1923, 2060-2066.

here acknowledges the assistance then given him by the engineering staff of the Bureau, the Director of the Department and of the city Bureau of Tests. The changes then made in the practice of the Bureau were the outcome of the co-operation, advice, and assistance of a number of men vitally interested in the subject. Improvements or changes must be measured in terms of relative economy; of practicability from an administrative standpoint; of feasibility; and many other factors. The necessity for improved methods in selecting materials was passed upon, and the changes in practice here described were devised as an organization problem, and therefore represent the consensus of opinion.

The principal requirements of concrete are that it shall have sufficient strength to withstand the imposed loads; that it be permanent and durable in character; and that it successfully resist such conditions or agencies as may impair its strength or tend to disintegrate it. These latter agencies are variable in kind and degree. They include atmospheric fumes and disintegrating agents, soil, surface water and rain water, industrial wastes, temperature changes, etc. The changes in municipal practice were directed mainly to concrete in bridges, street paving foundations, retaining walls, and similar construction.

Specifications. The specifications for sand and gravel which were superseded by the new specifications (which will be here stated) had been in effect for a number of years. They provided that the sand should be clean, screened Allegheny River sand, graded from fine to coarse, and free from coal, silt, organic or other foreign matter. Such a specification, if possible to follow in its entirety, would yield a perfect material; but such a specification, lacking definition and accommodation to actual conditions, cannot be enforced. Either the specifications must be framed to require a grade of commercial product as good as is available, or the standard of the product must be raised. In drawing the new specifications, it was intended to insure the use of good and suitable materials, so far as possible. Laboratory tests both of the materials themselves and of mortar and concrete cylinders were made from commercial samples in order to set a standard of available material. The various requirements were then set with regard to the two important points—the necessary standard for good concrete, and availability and practicability.

The specifications adopted, and here quoted from the edition of

August, 1922, of the Standard Contract for Street Improvement, were as follows:

"18. The sand for concrete and mortar shall be clean Allegheny River sand, or sand of equal quality. It shall be free from sticks and refuse, and shall not contain coal, loam, clay or silt in excess of the percentage hereafter stipulated in Section 22-B.

Sand at the source must be uniform in quality, with respect to color, silt, coal, organic matter and grading. Sand will not be accepted by the Director which is taken from barges that have not been cleaned previously to the placing of the sand therein, nor from bins, into which sand containing excessive silt or other foreign matter has been placed.

The sand shall be graded from fine to coarse and shall conform to the following mesh requirements:

Passing ¼-inch mesh screen	100%
Retained on 20-mesh screen	20 to 40%
Retained on 50-mesh screen	Not less than 70%
Passing 100-mesh screen	Not over 6%

19. The contractor shall advise the Director of the places from which the sand is being hauled, so that the sand may be passed upon for approval by the Director before same is actually delivered on the work. The contractor shall be responsible for ensuring that the sand is hauled only from approved stock.

20. The sand used on this contract will be subjected to tests and will be approved only after same have been satisfactorily passed.

The contractor, for his own protection, should make such tests as in his opinion may be necessary to protect his interests, and, in addition, the sand will be subjected to the following described tests by the city:

21. The contractor is required, at his own expense, to submit all sand offered for use on this work to the colorimetric test for the determination of organic impurities and to submit to the Director a properly certified copy of the result of said test.

22. The sand shall be subjected to the following tests to be made by the city: Sieve analysis, loam content, colorimetric test for organic impurities and compression tests in 2" x 4" cylinders at 7 and 28 days.

(a) When dry it shall all pass a screen having circular openings one-quarter (¼") inch in diameter.

(b) The sand shall not contain more than two (2%) per cent. by volume of coal, nor more than four (4%) per cent. by volume of silt, and the total percentage of coal, silt, or any other foreign matter must not be more than five (5%) per cent. by volume.

(c) The sand will be subjected to a twenty-four (24) hour colorimetric test in conformity with Abrams' method, and to be acceptable must be rated as either one (1) or two (2) by this method.

(d) The sand will be subjected to a seven (7) day and a twenty-eight (28) day compression test to develop the strength of 2" x 4" cylinders composed of the sand and Portland cement mixed in the proportions of one (1) of cement and three (3) of the sand offered for test. The cylinders shall develop at least eighty-five (85%) per cent. of the strength developed by similar cylinders made of the same cement and standard Ottawa sand.

23. The contractor will be permitted to use sand at his own risk which has satisfactorily passed the colorimetric and the sieve tests. The use of sand so tested and the acceptance of the concrete will be further subject to the seven (7) and twenty-eight (28) day compression tests, and if said tests are not passed the concrete shall be removed and replaced at the contractor's expense.

GRAVEL AND BROKEN STONE

24. Gravel used for concrete shall be clean, screened, Allegheny River gravel, free from loam, silt, sticks, coal and other foreign matter. The gravel shall be graded from fine to coarse, and, unless otherwise specified, shall pass through a screen with a two and one-half (2½") inch mesh and be retained on a sieve with a one-quarter (¼") inch mesh.

25. Broken stone used for concrete shall consist of fragments of hard, durable stone and, unless otherwise specified, broken to the sizes hereinbefore specified for gravel. It shall be screened, if necessary, and shall be evenly graded from fine to coarse, and shall conform in all other respects to the requirements for gravel."

In passing, it may be well to state that the new specifications contained additional provisions relating to the mixing and proportioning of concrete, including the regulation of water content, automatic timing, the admission of the slump test for openings in completed work, and increasing the proportion of cement in the various classes of concrete.

The earlier specifications, as before stated, admitted only Allegheny River sand. At that time no definite information was available as to Ohio River sand. The author believes that this restriction has since been lifted to permit the use of Ohio River sand from satisfactory locations.

Uniformity (Section 18). This is a most important provision in effective control, as otherwise the enforcement of the specifications is impracticable. For the same reason the cleanliness of barges and bins is important in order to insure a uniform delivery conforming to the tested and accepted samples.

Grading (Section 18). The relative fineness and grading of the sand is, in the author's opinion, a most important factor in the

strength and permanence of the concrete. The specifications were based largely on availability at the time. A coarser sand, with a proportion of grains between ¼ inch and ⅜ inch would give better results as to strength, density, and permanence. Increased cost, and difficulty in production would be justified by the results obtained. However, as the specification stands, it eliminates inferior material and the sand admitted, while not yielding a concrete as satisfactory as is economically possible with local materials, should give a satisfactory concrete for most purposes. The variability which has been noted in tests of many mortars and concrete samples has, by the author, been to some degree ascribed to relative fineness and grading of the sand. This factor is one worthy of extended study and investigation and of co-operative action by our material-producing companies and engineers.

Tests (Section 20). This is merely a general provision requiring the tests afterwards defined.

Tests (Section 22). Local river sands normally contain a percentage of loam and coal. If these impurities are not in excess, their presence cannot be considered objectionable; but there is a limit to the allowable percentage of either silt or coal, or of their combined percentage. The limiting percentages here fixed are conservative and feasible and the standards should be adhered to. Sand of this quality is readily obtainable at most times, and certainly sand containing higher percentages is subject to suspicion.

As it is recognized that organic matter may be contained in local river sands, the colorimetric test is to be regarded as one of the most necessary safeguards. As to whether or not such organic matter renders the sand unfit for use would seem to depend on its character and quantity. It may be present in such form and quantity as to prevent or seriously interfere with the setting up of the concrete, or impair its strength and durability. The colorimetric test devised by Professor Duff A. Abrams, of Lewis Institute, of Chicago, provides an excellent and simple test for the relative organic content of the sand sample. In the Abrams test, the relative organic content is indicated by color numbers from 1 to 5, based upon the color reactions after treating the sample with sodium hydroxid. The tests of local sands by the City Bureau of Tests indicated that it was safe to use a sand with a color test of 2 and that with reasonable care the adoption of such a limiting value would not interfere with production.

The many tests since made would seem to bear out the correctness of this decision. Excessive organic content does not necessarily mean that the sand is unfit for use, as the organic matter may be due to a high lignite content or may not be present in harmful form, but such sand must not be used until physical tests have demonstrated its suitability. The appearance of the sand and its apparent freedom from silt or foreign matter is no indication of its fitness for use.

Compression Test (Section 22). On account of the time required, and the impracticability of storage on many jobs, the compression test is to be regarded as a check-up following use, rather than as a requirement for acceptance. The provision that the sand in 1 to 3 mortar cylinders shall develop at least 85 per cent. of the strength developed by similar cylinders of the same cement and standard Ottawa sand should be, and as a matter of fact often is, exceeded by the sand which has passed the tests previously described.

Gravel (Section 24). The absence of uniform and generally accepted requirements for local river gravel have up to the present time prevented the formation of satisfactory general specifications with regard to grading quality and sizes. The result is that purchase and contract specification differ widely and, on the work, it is often found necessary to accept gravel which is in some respects unsatisfactory. If the requirements of the work are such as to demand concrete of high quality, gravel of the requisite quality and size can be procured only with considerable trouble and at excessive cost. This holds good particularly where time and space limitations prevent the screening and preparation of the gravel on the work, as in the case of most municipal contracts. The gravel, however, may be considered as a relatively unimportant factor as compared with such factors as the sand, cement, water ratio, and care in the mixing and placing. As a factor contributing to average strength, therefore, it was not thought to be as important; and, in view of the difficulties of making changes in the quality of gravel, the specification of 1922 did not differ materially from the previously existing specification. Reasonable care, however, has been used in excluding gravel which is either too fine or too coarse; which is noticeably inferior as to grading; and which contains an excessive amount of silt, coal, and other objectionable matter. Ordinarily, the gravel as delivered is fairly clean, although from time to time it was necessary to make rejections. Considerable improvement in the situation would result if well-graded

gravel of different sizes could be readily obtained, and, in view of the possible improvement in the quality of the concrete, an increased cost would be justified.

There should be further information with regard to the relative strengths of the different types of gravel which are delivered in the Pittsburgh district, and practicable tests should be devised to exclude gravel which may not be satisfactory for particular purposes. Along this line there should be tests to determine when the gravel contains an unduly large proportion of weak particles such as weakly cemented sand or particles liable to disintegration; also the effect of a large proportion of elongated and flat particles. It is not known how far these two conditions may affect the strength and performance of concrete subjected to severe requirements, and we should know more about them.

In addition, there should be some kind of a test to determine whether the gravel is coated with organic matter in such form and quantity as to weaken the concrete by affecting the bond with the mortar. The colorimetric tests for sand take care of sand admirably; it would be equally advantageous to have some such test for gravel.

Enforcement of Specifications. The enforcement of specifications is generally not less difficult, and often more difficult, than the formulating of their terms and requirements. One of the biggest problems confronting the Bureau was that of developing methods and means of insuring the enforcement of the specifications. The work of such an organization is diverse, including concrete in many classes of structures such as sewers, concrete retaining walls, concrete in pavements and pavement bases, street curbing, piers and abutments, bridges, reinforced arches, etc. This work is carried out under a very large number of contracts scattered over a large area, so that the supervisory force is necessarily relatively small and the work, as a rule, cannot be under the constant personal supervision of the responsible heads. Material is being constantly delivered on these jobs, generally by truck for immediate use, and hitherto inspection had necessarily been of superficial character. The working out of a simple and practical method of handling the problem which would attain results without requiring an undue amount of administrative attention therefore presented such difficulties that its solution was one of gradual development. Numerous staff meetings were held, and the following system was the outcome.

The principal elements to be considered in the control work embrace the following:

1. A definite system for supervisory work carrying out sampling, testing, reporting, and recording, properly co-ordinated with the supervisory organization of the Bureau.

2. That only tested and accepted material be accepted and used on the particular job.

3. That the heads of the various divisions be kept fully and promptly informed as to tests affecting their respective work, so that each may be able to take necessary action when conditions require.

4. That records as complete as possible be kept without duplication of effort on each concrete job.

The system as worked out in 1922 was as follows:

The sampling and testing of materials and of job concrete were placed under the immediate charge of an experienced engineer acting in the capacity of Supervisory Engineer of Tests. His duties, embracing both field and office work, included direction of men engaged in sampling and testing at the distribution points; co-ordination with the work of the City Bureau of Tests; compilation and recording of results; and issuance of reports to division heads.

A force of inspectors of material was organized and assigned to the various material plants, working under the instructions of the Supervisory Engineer. These men were instructed in the details of their duties in taking samples for such tests as were made at the City testing laboratory. A special inspector was also assigned to the taking of job concrete samples, as it was found that, unless extreme care was used in all details, the results in many cases were worthless.

The material inspector working at the float or other source of distribution took record of each delivery, this being either the car or barge number, took the necessary samples, noted the name of the sand company, and the date the sand was sampled, and assigned to each sample a division number so that all tests made for that delivery would be identified by the proper number. He entered this information on a card report known as a "sand report." On the same card he entered the results of the colorimetric, silt, and coal tests. One of these cards containing information identifying the delivery was given each truck driver and the delivery identified by stating on the card the time, truck number, license number, and similar data. This

card was then delivered by the truck driver to the job inspector, who noted thereon the time of arrival, his name, and a description of the work in which the sand was to be used (See Fig. 1).* The foregoing

CITY OF PITTSBURGH
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING

SAND REPORT

Date.....192.....

Contract.....

.....

1. Barge Number.....
2. Name of Sand Co.....
3. Date Sand Sampled.....
4. Division Sample Number.....
5. Laboratory Number.....
6. Color Test Number.....
7. % in 7-Day Test { Lbs. ..... / % .....
8. % in 28-Day Test { Lbs. ..... / % .....
9. Time Leaving Yard.....
10. Truck Number.....
11. License Number.....
12. Inspector at Barge.....
13. Time Arriving on Job.....
14. Inspector at Job.....
15. Description of Work in Which Sand Is to Be Used.....
.....
16. Remarks .....
.....
.....
.....

Fig. 1.

constitutes a definite record and is the assurance to the job inspector that the material has been properly sampled and tested.

The inspector turns over the same report or delivery card to the head of the division, who holds it, pending results of compression tests from the laboratory.

The material inspector makes a daily report to the Supervising Engineer, on a printed form, 8½ by 11 inches, like the following:

DEPARTMENT OF PUBLIC WORKS BUREAU OF ENGINEERING

INSPECTOR'S REPORT—SAND TESTS

NAME OF FLOAT..... .....INSPECTOR

Date	Barge No.	Company	Color Test	Silt Test	Coal Test	% of Sand Retained on ¼" Sieve	% of Sand Retained on No. 50 Sieve	% of Sand Passing No. 100 Sieve	Remarks

*Fig. 1-4 are actual copies of the cards used, slightly reduced in size. The other forms shown are set in type, from large sheets.

This report, which contains the identifying numbers and the results of the various tests, is mailed at the close of the day to the Supervising Engineer and is the basis for his action and records. Using this form, the Supervising Engineer then compiles a record of the tests made by the material inspector, adds thereto the reports on the laboratory tests, and transmits a copy to each division head, retaining a copy for his own records.

The next step is the testing of the concrete itself and the reports thereon. The job inspector makes a daily report on concrete work and the materials used therein on a small card form, which he mails or sends in daily to the division head (See Fig. 2). This contains

CITY OF PITTSBURGH
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING
Inspector's Daily Report of Concrete Work & Materials

Date _____ 192____
Contract _____
Kind of Work _____
Location _____
_____
Temperature (Weather) _____
Approximate Quantity _____

CEMENT
Division No. _____
Car No. _____
Lab. No. _____
Brand of Cement _____

SAND
Barge No. _____
Sand Company _____
Date Received _____

CONCRETE SAMPLES
No. _____
No. _____
No. _____
No. _____
No. _____

_____
Inspector.

Fig. 2.

information identifying the nature and location of the work, and constitutes a record of the cement and sand used, so as to tie up properly with the cement and sand tests. The job inspector further notes on this card the samples of concrete taken for compression tests.

The samples of field concrete for testing are not taken by the job

inspector, but by specially trained inspectors. The concrete sampler makes a daily report, listing all samples taken for the day. This form lists the various samples by sample number, identifies the contract, gives the name of the inspector, the mix, the kind of work, and the location. This report goes to the Supervising Engineer. This form also contains spaces for recording the breaking tests of the cylinders for the different periods, which information is later entered by the Supervising Engineer from laboratory reports received as the samples are broken. This constitutes the Supervising Engineer's office record. The following form is used:

DEPARTMENT OF PUBLIC WORKS BUREAU OF ENGINEERING

DAILY REPORT OF CONCRETE SAMPLER

DATE..... .....SAMPLER

Sample No.	Contract for (A) Name of Contractor	Inspector	Mix	Kind of work	Location and Remarks	Compression Test			
						Lab. No.	7 Day	14 Day	28 Day

(A) Indicate as follows—Grading, Paving & Curbing (G. P. & C.) Repaving (Rep.) Sewer (S) Bridge (B).

As the concrete samples are tested, a report for each job is issued by the laboratory on a compression test card (See Fig. 3). This

CITY OF PITTSBURGH
DEPARTMENT OF PUBLIC WORKS
BUREAU OF TESTS

COMPRESSION TEST
6″ CONCRETE CYLINDERS

LOCATION DATA

MADE BY

LAB. NO.	CYL. NO.	MIX	DATE MIXED	AGE	TEMPERATURE		LBS PER SQ IN
					AIR	CONCRETE	

CONTRACTOR INSPECTOR

DIV. ENG. REMARKS

DIRECTOR OF TESTS

Fig. 3.

goes to the Supervising Engineer, who transmits it promptly to the division head so that any necessary action thereon may be taken. The information as to the compression tests is then entered by the Super-

vising Engineer on the form shown above, headed "Daily Report of Concrete Sampler." The laboratory report on cement tests is made in the same manner on a form (See Fig. 4), which is sent to the

CITY OF PITTSBURGH
DEPARTMENT OF PUBLIC WORKS
BUREAU OF TESTS
REPORT OF CEMENT TEST

LAB. No.	BRAND			DATE SAMP.		
					DATE REC'D	
SHIPMENT	PLACE OF COLLECTION				DATE TESTED	
FINENESS	RET. ON 200	%	WATER USED	%	SP. GR.	
SETTING	INITIAL HRS.	MIN.	FINAL HRS.	MIN.	BOILING TEST	
STRENGTH	1	2	3	4	5	AVERAGE
7 DAY 1/3 STD. SAND						
28 DAY 1/3 STD. SAND						

CONTRACTOR INSPECTOR

DIV. ENG. REMARKS

CAR No. DIRECTOR OF TESTS

Fig. 4.

Supervising Engineer and, after being recorded by him, is sent to the various division heads. The final job records are kept by the division heads from the foregoing information furnished by the Supervising Engineer in the laboratory. These records are kept on a tabular form, which contains a combination of all the records as to the materials and the tests of the concrete.

The end result desired is good concrete, and the writer believes that the revision of the specifications and the establishment of the system of control over concrete work has notably improved the quality of the work. The final measure of the quality of the concrete—and this includes the suitability of the sand and gravel together with all the other factors—is in the permanence of the work. The closest approximation to this at the time of construction is the testing of field samples of the concrete. The results of such tests, when properly made, and when supplemented by the tests of the constituent materials, are indispensable for the proper supervision of the work. It must, however, be borne in mind that the effect of all the factors is merged in the tests of the field concrete. Even if the best sand and gravel be used, it cannot be expected that the concrete will be satisfactory if improper construction methods are used. Lack of thorough

mixing, excessive use of water, segregation in transportation and handling, and exposure to low temperature in cold weather, are frequent causes of concrete failures and lack of durability. These points are here mentioned so that the proper perspective will not be lost sight of, and undue attention be given the selection of the material to the neglect of other important factors.

The writer believes that the conditions with regard to improvement in quality and uniformity of local material could be improved by the adoption of more uniform specifications by the various users and by helpful co-operation between the producers and engineers, architects, and other users. There is no doubt that at the present time, by the use of reasonable care, suitable sand and gravel can be obtained, but the raising of the standard depends very largely on the development of the possibilities of technical requirements and of economic supply.

While the specifications above described should be satisfactory for the class of work they are intended to cover, they cannot be considered sufficient for concrete where high stresses are involved. Work of such character, irrespective of the local situation, calls for very careful selection of materials and the use of carefully considered operation plans—otherwise the use of high unit stresses is not justified or safe. It will be borne in mind, therefore, that the requirements here stated were intended for a particular purpose and not for application to all classes of construction. The requirements are carried only so far as economically possible for the desired result.

PRODUCTION OF RIVER SAND AND GRAVEL

By A. W. Dann*

The greater part of the sand and gravel used for building purposes in the Pittsburgh district is obtained from the Allegheny and Ohio rivers. The material in the Monongahela River is not generally suitable for the purpose. There is some production from the Cheat River, as well as a quantity reclaimed by bank operation at points near New Castle and Beaver.

There are 20 dredges in local waters engaged in production from the two rivers. These dredges are all of the endless-chain type,

*Vice-President and Treasurer, Keystone Sand & Supply Co., Pittsburgh.

but vary in size from quite small ones of, say, 40 tons per hour capacity, to those of elaborate design, costing several hundred thousand dollars and with capacity of 400 or 500 tons per hour. The use of steam for driving power is the general practice, although this is varied in one place by the conversion of power into electric energy before application. In another case, steam is abandoned altogether and oil-burning engines drive the dynamo by which individual motors are driven. The older boats are self propelled and of wooden hull construction, while the newer ones are largely of steel construction throughout, with no means of propulsion.

Each dredge is a self-contained production plant, from which sand is delivered to barges on one side and gravel of one or more sizes on the other side, each ready for market. The depth of the sand and gravel deposit varies from 25 to 50 feet below water surface, at which point rock is generally encountered. Few of the dredges are capable of reaching the greater depth. It is usually in the stratum immediately above the rock that the greater percentage of sand exists.

The material coming from the river bottom is subjected to the washing action by water from the time it leaves the digging buckets until it is re-elevated for discharge to barges. In general practice, it is first screened with water playing on it, the sand and gravel each going to a rewashing tank, from which silt, as well as sticks and fine coal, if present, are overflowed. From these tanks it is re-elevated for discharge to barges. Loam contained in the finished product is frequently lower than 1.5 per cent.

Transportation of material from dredges to points of distribution is accomplished in barges of wood or steel, varying in capacity from 100 tons to 750 tons; the larger steel ones being, of course, more in keeping with large modern dredges. The types of propelling boats include high- and low-pressure steam, stern-wheel boats; tunnel boats; gasoline-engine boats; and those equipped with fuel-oil burning engines.

Gravel is produced in a large variety of sizes, both with reference to the upper and lower limits. Lower limits vary from 3/16 inch to ¾ inch, and upper limits from ¾ inch to three inches, depending upon specification. The greatest demand is for gravel with all above 1½ inches removed, even when three-inch gravel would perhaps make a better concrete.

Sand is produced in 3/16-inch and ¼-inch sizes. This size refers to the square opening in the sand screen. It is necessary to produce the smaller size for bricklaying mortar and for plastering, but it is realized that the coarser sand is preferable for concrete aggregate. If there were a greater demand for the larger size, producers would gladly arrange to supply it. Most buyers object to the coarse sand, probably because they wish to use it from the same pile for bricklaying and for concreting.

It is quite generally thought that the deposits of sand and gravel in the rivers are renewed by the erosion of floods. It is true that sometimes excellent material can be obtained by going over the ground a second time, but more frequently the holes are filled with mud. It is bound to become increasingly difficult, and consequently more expensive, to produce these materials of satisfactory quality in this district.

When the deposits are worked, there is obtained around 65 per cent. of gravel and 35 per cent. of sand. The demand for sand about equals the demand for gravel, and hence the surplus gravel must be run back into the river, causing a great waste of good material. We know of no other locality where this condition obtains. The proportion is usually better balanced or else there is a surplus of sand. The sand industry has given much thought to developing some means of producing a satisfactory sand from gravel at a cost which would justify the operation. This is a reduction about which we find the manufacturers of crushing machinery in complete ignorance.

In trying to work out the problem, difficulty was encountered in the hardness and abrasiveness of the gravel and consequent excessive wear on crushers, as well as in the tendency to produce too much fine and coarse material in the bottom and top sizes of the product, respectively, with not enough intermediate sizes. In other words, the screen analysis was not good. At least such was our own experience, although we cannot speak for those other than ourselves who have been working on the problem. Following the construction and operation of a small experimental plant, with which a large number of varying tests were made, with subsequent screen analysis, our company has built, and now has almost ready for operation, a crushing and screening plant which should produce about 100 tons of sand per hour. Results revealed by the examination of small quanti-

ties run through the plant show even better performance than was indicated by the experimental plant.

Sand and gravel production in the Pittsburgh district, as elsewhere in the United States, began with no greater equipment than a shovel and wheelbarrow, with perhaps a skiff; and, in a comparatively short period of time, has grown with the construction industry until it engages the attention of many men and much capital. In early years neither the producer nor the consumer knew or cared much about quality. Now this is changed, and they are both concerned with quality, and each because he knows that it is for his best interest to be so concerned. Our company has for some time had regular tests made of material lifted at the dredges as an aid to quality maintenance. Properly washed and graded aggregates mixed according to best engineering practice with well-manufactured cement should make enduring concrete. Hardly can it last without these things. The sand and gravel producers recognize their responsibility in this matter and are more and more trying properly to discharge it.

TESTS TO DETERMINE THE SUITABILITY OF FINE AND COARSE AGGREGATE

By P. J. Freeman*

The aggregate comprises from 80 to 85 per cent. of the volume of concrete, and engineers and contractors are beginning to realize that it is just as important to know the quality of the aggregate which they are using in a structure as to know the quality of the cement. Unfortunately, however, at this time we do not have any complete set of tests and specifications to which we can refer and be certain that the entire matter will be completely covered.

It is easy for the engineer to specify that the Portland cement shall meet the requirements of specification C 9-21 of the American Society for Testing Materials and thus not only cover the present-day specifications for quality, but also the exact methods for sampling and testing. This has been brought about by the co-operation of the producers and users of cement working together on committees during the past fifteen years, and it is hoped that this meeting will open the way for a similar condition in this district concerning concrete aggregates.

*Consulting Engineer, Pittsburgh.

It is unfortunate that at this time the various national societies have not been able to agree on standard specifications and tests, but it has been possible to develop some methods for testing which furnish information that may be used in drawing specifications. The various state highway departments have drawn specifications and developed methods for testing, but until recently they were sadly lacking in uniformity. This made it possible for a material to be rejected in one state and entirely acceptable to the engineers of an adjoining state. This is being remedied by the State Highway Testing Engineers and Chemists, who are co-operating to produce uniform requirements.

In the Pittsburgh district it not infrequently occurs that aggregates which are rejected by one engineer are used by another on equally important work. The fact that the requirements are far from standardized in this district works a hardship on the producer and adds to the cost of the materials.

No responsible producer desires to furnish material which will not make first-class concrete, and at least one producer is making systematic tests of his materials to enable him to maintain a high standard of quality.

Among engineers, there is an increasing demand for tests of aggregates, and there will probably be a demand for a change in the requirements for aggregates. It is not desirable for one or two users to set a certain standard for aggregate, as the cost of producing any special kind would probably be prohibitive; but, if the entire body of users agree with the producers that a certain class of aggregates shall be produced—as, for example, to raise the size of fine aggregate from all passing a No. 4 sieve (which has an opening only 0.187 inch) to a ⅜-inch sieve, the quantity of sand, as well as the mortar strength, would be greatly increased in this district.

The two customary reasons for testing the aggregates are:

1. To enable the engineer to select the proper materials and suitable proportions for the concrete.

2. To assure the engineer that the specified conditions are being met.

There is another reason which the engineer too often overlooks, and that is to have a complete and systematic record of tests of all materials to protect his reputation in that connection in case any kind of failure should develop in the structure. The engineer is placed in

a sorry plight if, after a number of years, he is required to show that he performed his services properly and then is not able to produce at least a few records of tests of aggregates to prove that he had attempted to satisfy himself that the materials were suitable for the work in hand. It matters not what the nature of the failure is; since the aggregates comprise the bulk of the concrete they are always considered in such an investigation, even though the fault may be found in the design.

Recent investigation has indicated that in the production of strong concrete the fine aggregate is of more importance than the coarse aggregate. Tests made by the speaker some years ago on slag concretes showed that about the same strength was obtained on slags weighing only 64 pounds per cubic foot as on those weighing 82 pounds.* The same thing was pointed out by Raymond Harsch in a paper before the American Society for Testing Materials last June.†

Similar results were obtained from tests on the very light weight aggregates used for concrete ships. It is therefore important that the greatest care be used in the selection of the best fine aggregate which is *economically available* for that particular job.

For determining the suitability of natural sands for use in concrete, it is becoming customary to make the following tests:

1. Sieve analysis: American Society for Testing Materials, specification C 41-22.

2. Decantation test for loam and silt: American Society for Testing Materials, specification D 74-21.

3. Colorimetric test for organic matter: American Society for Testing Materials, specification C 40-22.

4. Mortar strength: American Society for Testing Materials, specification C 9-16 T.

Sieve Analysis. All scientific methods for proportioning concrete are based on the sieve analysis. During the last three or four years a number of researches have been published indicating methods for using the sieve analysis in connection with obtaining correct proportions of aggregate to meet the requirements of any particular concrete problem.

*Tests of blast furnace slag as the coarse aggregate in concrete. (In Proceedings of the American Concrete Institute, 1918, v. 14, pp. 95-99.)

†Blast furnace slag as an aggregate in concrete. (In Trans. A.S.T.M., 1923, v. 23, pt. 2, pp. 255-273.)

The United States Office of Public Roads* has pointed out the fact that the aggregate produced by commercial screens is determined by one or more of the following factors, which are independent of the size of the opening:

a. Thickness of plate.
b. Diameter of screen.
c. Wear on plate.
d. Length of screen.
e. Inclination of screen.
f. Rate of rotation.
g. Rate of feed.
h. Wet or dry screening.

It will be seen, therefore, that to obtain the actual sizes of material it is necessary to have a special sieve analysis. This is made on a carefully quartered and dried sample and furnishes information as to the probable mortar strength as well as general suitability.

Decantation Test. The amount of loam or silt which may be floated out is determined by the decantation test, and it is necessary that the value be kept low, particularly for reinforced concrete. The decantation test should not be confused with the various field tests for loam in which the percentage by *volume* is determined by using some sort of graduated cylinder. The volume tests give higher values, and specifications drawn for the decantation method will frequently be difficult to meet if tests are made by the volume method. Such field tests are very useful in the field, as they may be made where the work is going on and give approximate checks on the material, but the values should be compared with results made by the standard decantation method.

Organic Impurities. The test for organic impurities is made by placing a quantity of sand in a bottle containing a three per cent. solution of sodium hydroxid, and noting the color at the end of 24 hours. If the color is dark, the sand should be looked upon with suspicion, but it is quite possible that the color is produced by very small quantities of lignite, tan-bark, or coal which has been partially decomposed by very dilute sulphuric acid. This condition sometimes occurs in the Pittsburgh district and, if the sands are tested for mortar strength, they are found to be very satisfactory.

*Public Roads, v. 1, June 1918, pp. 35-48; v. 2, June 1919, pp. 35-40.

Mortar-Strength Tests. Since concrete is always used in compression, it is very desirable to have the mortar-strength tests made in the same way. The mix should also be proportioned by volume rather than by weight. Fine sands usually show about the same strength relative to Ottawa sand whether tested in compression or tension, but sands which are coarse usually show a higher relative strength when tested in compression.

The mortar-strength test is the best method of determining the strength of fine aggregate, as it has been found that the compressive strength of the mortar very closely indicates the relative strength of the concrete which can be made with the sand and any reasonably good coarse aggregate. From recent tests of cores drilled from finished concrete, it seems probable that the compressive strength of the mortar more closely represents the strength of the finished concrete in the field than do the results of preliminary laboratory tests of the cement, sand, and aggregate. In other words, the sand and cement seem to be the controlling factors in the strength of concrete; and the weight, density, or strength of the coarse aggregate are not so important, provided they are reasonably satisfactory.

Selecting Coarse Aggregate. To determine the tests necessary to select a satisfactory coarse aggregate one must know the nature of the service and the mix to be used.

If the concrete is to be exposed to severe freezing and thawing it will be necessary to determine if the aggregate is proof against weathering. If it is not, then the concrete made with such an aggregate will be quite likely to disintegrate with age unless the effect of such action of the elements is retarded by using more cement than would ordinarily be specified. For example, the investigation of a particular structure which was about ten years old showed that with the same materials used throughout the 1 : 1½ : 3 concrete was like flint, the 1 : 2 : 4 concrete was satisfactory, but the 1 : 3 : 6 concrete was disintegrating very badly. With present information, suitable tests could have been made at the beginning to ascertain if the aggregate would be susceptible to frost action, and the mix proportioned to suit, if it were economically necessary to use that particular aggregate.

Sieve Analysis. The sieve analysis of coarse aggregate should be made for the same reasons that it is made on the fine aggregate, as it

is necessary to grade and proportion the mix properly if water-tight and impermeable concrete is to be made.

Organic Impurities. The colorimetric test for organic impurities was not developed for coarse aggregate, as the *injurious organic impurities* which are usually feared are in the nature of humus matter, which creates a film over the fine particles, and usually such material is absent from coarse aggregate. If it is thought necessary, a modified form of the test may be made on gravel, using a wide-mouth bottle, and interpreting the results in accordance with the amount of solution used. As a general rule, however, if the gravel does not contain an excess of clay and loam, the test will not show any color value.

Clay and Loam Tests. Washing tests for clay and loam are not made on any coarse aggregate excepting on gravel, and that is not often done unless the gravel appears to be very dirty. The appearance of gravel is very deceptive, as it will seem to be perfectly clean when first washed and still wet, and later, when dry, it may seem to be dirty. Careful washing tests will seldom show a very high percentage of loss under such circumstances, as the coating is usually very fine sand.

Tests of Highway Materials. The amount of concrete to be placed will have a considerable bearing on the tests which should be made on a coarse aggregate for mass construction, but for the wearing course of streets and highways and similar work where the concrete is subjected to unusually severe service and abrasion, there are a number of tests which are applied.

The Deval abrasion test for loss by wear was first devised by M. Deval as a test for stone to be used in macadam roads in France, and it was later introduced into this country and has been the most commonly used test for rock to be used in concrete roads. It does not give satisfactory results when used on gravel, and it has been modified by various engineers when used for that purpose.

There are a number of tests which are often applied to rock which is to be used for the coarse aggregate in highway construction, but the toughness, hardness, and compression tests are the most common ones. These are made on cylinders drilled from the solid rock, and it is therefore necessary to have rather large pieces to make the cores.

The interpretation of these tests for highway construction is

largely covered by the present specifications of the various states and need not be discussed here. They are seldom used in the selection of aggregate for mass or reinforced construction, but would be very valuable if the engineer had a complete record of the durability of various materials which had been subjected to these tests, as the data would enable him to judge the quality of a new material in the light of the tests and the performance of the material in the past.

Summary. In planning a series of tests or interpreting the results it should always be borne in mind that the ultimate aim is to produce a durable and satisfactory concrete at the lowest cost. Strength cannot always be used as the guide, for it may be necessary to have excess strength in order to obtain an impermeable and durable concrete.

For some purposes the results of tests must be interpreted in the light of field experience, and materials which show a very satisfactory strength should be discarded for reasons which cannot always be demonstrated by tests. It has been found necessary in some instances to resort to a geological study of the rocks to know their character and composition in order to be able to say whether there might be any fundamental elements lacking in the rock structure which might permit the material to disintegrate with frost action.

With the results of the sieve analysis, decantation, organic matter, and mortar-strength tests on a natural sand, the engineer can pass an opinion as to quality:

1. If the grading is uniform, and it contains no organic matter nor an excess of loam, the compressive strength ratio to Ottawa standard sand will probably be at least 100 per cent. Such a sand would be satisfactory for any kind of concrete.

2. If a natural sand is well graded, with a low percentage of loam, but the organic-matter test shows a dark color, the strength may be below that of standard sand mortar, in which case the sand should be rejected. It is sometimes found, however, that the dark color is formed by lignite or similar material in minute quantities, and in that case the strength of the sand will not be lowered, but will be satisfactory.

3. If the sand shows an unsatisfactory grading, and is free from organic matter but contains an excess of loam, the mortar strength will probably be low; but such sand may sometimes be used

for unimportant work with the addition of cement to make up the deficiency in strength.

4. A sand showing a good grading, no organic matter, and a high compressive strength, but with a large amount of loam, should not be used for reinforced concrete, without washing.

5. In determining the suitability of screenings for concrete, one must not be misled by the fact that a high mortar strength will usually be obtained even though the screenings contain a large amount of dust. No screenings should be used which will not comply with customary specifications for natural sands. In addition, it is necessary to know the ability of that particular material to resist the action of freezing and thawing if the concrete is to be exposed to the weather.

6. The coarse aggregate should be selected on the same general lines as the fine aggregate as to durability, with special attention to the choice of materials as to workability, in order to produce an impermeable concrete with the strength and other factors needed for that particular job.

CONCRETE AND CONCRETE MATERIALS

By J. J. Paine*

Many materials have been used for centuries in construction work without much knowledge of their ultimate nature or composition. But to-day, when we are building Woolworth buildings, Roosevelt dams, Hudson River bridges or street pavements to carry the increasing loads, approximations must be replaced by facts, and it is necessary to know exactly what to expect of a material under given conditions. To obtain these facts, testing apparatus and laboratories have been developed which imitate as closely as possible the conditions under which the materials will be used, and the trend of modern testing practice is to standardize these arrangements in order. I refer only to the actual practice and not to the great amount of research work being done where we are finding the results of varying the composition or conditions.

Each year we see more and more specifications and requirements demanded by users, and it is only a matter of time until the producer

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or furnisher of each material must be able to state and guarantee the qualities of his product definitely. The more advanced and far-seeing producer is taking this attitude; he wants his material tested and its worth proven. Furthermore, testing is the best kind of protection, not only to the consumer, but to the producer.

As our discussion is principally on concrete and our time is very limited, I will attempt only a brief outline of the standard methods of testing the materials used in concrete. These are the regular methods of the American Society for Testing Materials or American Concrete Institute adapted to our local conditions. There are also many other excellent suggestions offered by the Portland Cement Association, the American Society of Civil Engineers, the American Railway Engineering Association, and other sources.

Coarse Aggregate. The coarse aggregate may consist of gravel, crushed stone or crushed slag.

The gravel, crushed stone or crushed slag should be uniformly graded and should conform to the following requirements: 100 per cent. shall pass through circular openings not more than 2¾ inches in diameter; 35 to 45 per cent. shall pass a laboratory screen having 1¼-inch circular openings. Not more than 15 per cent., by weight, shall pass a laboratory screen having ⅝-inch circular openings.

The uniformly graded gravel shall consist of clean, tough, durable stone of high resistance to abrasion, free from loam, silt, sticks, coal, and other foreign matter. Gravel which contains disintegrated or soft stone, or shale, or an excess of flat pieces, should not be used.

The uniformly graded crushed stone shall be from clean, tough, durable rock, of high resistance to abrasion. This material shall be free from dust and an excess of flat and elongated pieces.

The uniformly graded crushed slag shall consist of tough, durable pieces, non-glassy in character. It shall be air cooled and shall have been exposed to the weather for a suitable time prior to use. The dried slag, when shaken to refusal, shall have a weight per cubic foot of not less than 65 pounds.

Abrasion is determined by the Deval or D 2-08 test of the American Society for Testing Materials.

Toughness is determined by the D 3-18 test of the American Society for Testing Materials.

Clay and silt in gravel are determined by the D 72-21 test of the American Society for Testing Materials.

Fine Aggregate. Sand, slag, or stone screenings for concrete should consist of clean, hard, durable grains or pieces uniformly graded from coarse to fine, with the coarse particles predominating, and should be free from lumps of clay, coal, organic matter, dust, or other deleterious substances. When dry, it should pass a laboratory screen having openings 3/8 inch in diameter; not more than 25 per cent., by weight, shall pass a standard No. 50 laboratory sieve, and not more than six per cent., by weight, shall pass a No. 100 laboratory sieve. It shall contain not more than five per cent., by volume, of foreign substances.

Mortar, composed of one part, by volume, of Portland cement and three parts, by volume, of fine aggregate, should have a compressive strength at the age of 7 and 28 days of not less than 90 per cent. of that developed by mortar of the same proportions and the same consistency, made of the same cement and standard Ottawa sand.

The fine aggregate should not contain more than two per cent., by volume, of coal, nor more than four per cent., by volume, of loam or silt; and the total percentage of coal, silt or other foreign matter must not be more than five per cent., by volume.

The sand should be subjected to a 24-hour colorimetric test in conformity with the Abrams method, and to be acceptable must be rated not more than 2 by this method.

Besides the above tests, the modulus of fineness may be determined; also a chemical and microscopic examination may be made to determine the composition and how the grains are cemented together.

The sieve analysis should be made on a sample carefully dried to constant weight at a temperature between 100 and 110 degrees C., according to method C 41-22 of the American Society for Testing Materials.

Mortar-strength tests are made in accordance with method C 9-16 T of the American Society for Testing Materials. Although the mortar-strength test is considered the criterion by which to judge a fine aggregate, it does not tell the whole story. Often fine aggregates containing a high percentage of silt or dust show excellent tests, but disintegrate more rapidly than those of lower strength.

Our laboratory has found that, on an average, one per cent. of coal will decrease the strength of mortar cylinders about five per cent. The coal may be separated from the aggregate by agitating the mixture with carbon tetrachlorid. The clay and silt may be determined by method D 74-21 of the American Society for Testing Materials.

The test for organic impurities is conducted according to method C 40-22 of the American Society for Testing Materials. Small pieces of wood, sawdust, or lignite will produce a marked color, but, in small quantities, are not considered serious.

Cement. The cement should meet the requirements of the "Standard Specifications and Tests for Portland Cement," adopted by the American Society for Testing Materials, September 1, 1916, with all subsequent amendments and additions thereto, adopted by this Society. At present the serial designation of the specification is C 9-21.

Our laboratory has been doing considerable chemical research on cement, and I am of the opinion that before many years many of us will have to make some radical changes in our preconceived ideas about cement. The essential components of cement are supposed to be tricalcium silicate ($3\ CaOSiO_2$), dicalcium silicate ($2CaOSiO_2$), and tricalcium aluminate ($3\ CaOAl_2O_3$). Upon the addition of water, these components hydrate at various speeds into crystalline forms of hydrated lime and monosilicates. Like other chemical reactions, mass action is involved, and I believe that the above completed reaction is approached only in the presence of excess water.

There are many other problems of interest, such as eutectic points and variations caused by small amounts of different substances.

Admixtures. There are a large number of densifiers, accelerators, hardeners, and waterproofing, tempering, and curing agents on the market. A few are based on scientific principles and are meritorious. Most of these are stearates or palmitates of ammonia, calcium, or aluminum, which react with any free lime (or lime set free when cement hydrates) and form insoluble compounds. Most accelerators, and tempering and curing agents are principally calcium chlorid.

A solution of magnesium fluorosilicate applied several times to set concrete gives it a hard, glassy surface and is an excellent method of preventing "dusting."

Concrete. In the testing of concrete, there are two tests of major importance. These are the compression or strength tests made from concrete samples 7 and 28 days old, respectively, and the slump test made during actual operation or while the concrete is being cast.

The method used in making and storing specimens of concrete in the field is very similar to the C 31-21 method of the American Society for Testing Materials. Six by 12-inch fiber cans, coated with paraffin on the inside, are used for molds. Concrete for the test specimens is taken with a scoop (so that no grout or liquid part will be lost) from the work immediately after it has been placed. Extreme care is taken to eliminate all air pockets and the sample is thoroughly puddled to make it homogeneous. In other words, we try to make the very best sample possible from the given materials. This is only fair, as we find that cores drilled from the completed work usually show greater strength than the specimens at the same age. The specimens or cylinders are immediately placed in a water-tight box having an elevated false floor or rack, so that water can be kept in the bottom; or they may be set on boards, paper lids placed over them, and then covered with sand. After five days the cylinders are taken to the laboratory and capped with a mixture of Portland cement and plaster-of-Paris. Care is taken to store the cylinders in an atmosphere saturated with moisture and kept as nearly as possible at 70 degrees F. until ready to be crushed. It is essential that the cylinders be handled carefully at all times.

The slump test is a relative measure of the consistency and made with a 6- by 12-inch fiber can or standard sheet-metal frustum of a cone, 4 inches in diameter at the top, 8 inches at the bottom, and 12 inches high. The form is carefully filled with concrete that has just been placed in the work, a rule placed alongside and the form quickly lifted vertically. The settlement or slump of the concrete is immediately noted.

The "Progress Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete" recommends the following maximum slumps:

1. Mass concrete ..... 2 inches
2. Reinforced concrete:
   Thin vertical sections..... 6 inches

Heavy sections	2 inches
Thin confined horizontal sections	8 inches

3. Road and pavements:

Hand finished	4 inches
Machine finished	1 inch

4. Mortar for floor finish..... 2 inches

Assuming that the materials have been tested and found satisfactory, the dividing line between good and bad concrete depends on the water content. All engineers seem to know that freezing, lean mixes, or rapid drying, produces bad concrete, but still it seems hard for some of them to realize that water content is just as serious. The fact that the strength of concrete depends on the ratio of mixing water and the volume of cement should be thoroughly understood. Usually five or six gallons of water per sack of cement is good practice.

An actual demonstration of these facts may be cited. A few months ago a certain contractor of this city was laying two different street bases on the same day with the same brand of cement and aggregates from the same source. On one job the City inspector was carefully checking the volume of aggregates and cement going into the mixer, and allowing the concrete to come out flooded and sloppy. On the other job, the City inspector was watching the consistency of the concrete. It was coming out mushy and plastic. The latter concrete, having the same mix, the same materials, and with other conditions the same as the first, tested 200 per cent. higher at seven days.

As an easy, simple, and practical control test, the slump test cannot be too highly recommended.

A permeability test is often worth while, as the quality of concrete depends to a great extent on its density.

Each year we are becoming more and more enlightened regarding the ultimate nature of concrete, and I believe that in the near future we will demand and pay for concrete on a quality basis.

CONTROL AND RECORDS OF CONCRETE CONSTRUCTION

By J. D. Stevenson*

In the control of concrete construction and the recording of the results of various tests, only the method in use in the Division of Bridges of this city is given. While the various tests of the materials entering into the concrete are made in different departments of the city's engineering organization, the collecting and recording of the data are among the duties of the division having charge of the construction of the work in question.

In the Division of Bridges the inspector on the job is provided with white-print plans and, if necessary, elevations, showing the work in question, together with white-print tables for the listing of the data. On the plan, each particular pour of concrete is marked and designated by a letter, while on the table the inspector records the sand used, the cement used and the concrete cylinder samples taken of that particular pour. The cement is either designated by car number and date of receipt or, when received in small shipments, by the date on which the sample was taken to the laboratory. The sand is recorded by barge number and date of sampling, this information coming on the card from the inspector at the sand float upon delivery there. The concrete cylinders are known by the cylinder number, which number is given to the inspector on the work by the concrete sampler making the cylinders. This information is sent to the office for record once a week. Complete data on the sand, cement and concrete are received from the laboratory and the supervising engineer of tests as the different tests are made. It is of utmost importance to know if the concrete is running low on the seven-day tests without waiting for the result of the 28-day test.

This information is then collected in the form of a table and kept as a permanent record, which record assembles in one place all the available information on the cement, the sand, and the concrete cylinders. The records of the pouring of the paving base for the Forbes Street bridge over the Pittsburgh Junction Railroad are used as an example of a typical job, on account of the simplicity of the records.

Testing of sand for concrete started in the Division of Bridges

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in September of 1920. At this time the foundations for the Schenley Park grand stand were being constructed. The concrete in one of the column foundations did not set up properly after several days, and in the ensuing investigation samples of both the sand and the gravel were taken to the laboratory for analysis. While the tests of the gravel revealed no weakness, the sand showed considerable coal and ran No. 4 in the Abrams color test. When tested for tension in a briquet, a strength of but 137 pounds in seven days and 175 pounds in 28 days was developed—about half what would be expected. The second series of tests ran 130 pounds in seven days and 202 pounds in 28 days. Each test given is the average of four briquets. In connection with the latter test, the same cement was used, together with standard Ottawa sand, developing 304 pounds in seven days and 366 pounds in 28 days. The faulty concrete was removed, and since that time all sand used by the Division of Bridges has been tested.

The above is given as an illustration of the necessity for testing sand before its use in concrete. While in this particular case the defective concrete would have been removed regardless of the results of the tests, the sand might easily have been used where the setting of the concrete could not have been readily observed. There are no means of telling whether this concrete would ever have become sound, but the indications are that it would have remained an extremely weak spot in the structure and could easily have resulted in failure. The simplicity of the Abrams color test and the ease with which it is made certainly seem to justify its use on all sands for concrete where the concrete is of sufficient importance to be placed under a specification.

Compression tests are now being used in place of the tensile tests with which the testing of sand started. It is very rare, however, that a sand rating 1 or 2 by the Abrams chart does not stand up well in the compression tests. Moreover, the personal equation in the color tests is very limited in comparison with that in the compression tests. As an example, in the reports from the laboratory the standard sand with the cement had a compressive strength in seven days of 1008 pounds. The river sand with the same cement was running approximately the same strength. A new man was placed on the making of the mortar cylinders and four seven-day tests ran 2217 pounds, 2267 pounds, 2817 pounds and 3125 pounds. The only explanation which

could be found was that the mortar had been tamped more tightly into the forms.

All concrete compression tests which fall below 1000 pounds are immediately investigated. With the test on sand and cement and with the water and mixing under control, the investigations have really revealed but little in determining the cause of the weakness in the concrete. On concrete where the tests fall below 1000 pounds there has been only one feature which showed up consistently, and that is in the use of pea gravel for concrete in protection for steelwork, in parapets, and other small sections where a coarse grade of gravel cannot be used. While practically all of the tests on this grade of concrete fall below 1000 pounds, it must be remembered that it is very difficult to get a representative sample from small forms, if complicated by reinforcement.

On one job the seven-day cylinders were running from 500 to 1000 pounds, with three around 1500 pounds, and averaging 795 pounds for 32 cylinders. Both the sand and the cement met the specified requirements, the sand and gravel were properly measured, and a fairly dry concrete was being used. The sand, gravel, and cement were sent from the job to the laboratory and concrete for the cylinders mixed in the laboratory in order to obtain as good a concrete as was possible with these materials. Two seven-day tests ran 666 pounds and 791 pounds, respectively, averaging 729 pounds—nine per cent. below the average of those taken in the field. There was evidently something wrong with the materials for this concrete, but the exact fault was never ascertained.

In the investigation of failure of the tests to meet the 1000-pound requirement, considerable information was obtained on the handling of the cylinders. In the sampling it is necessary to take the concrete from the mass being poured. A concrete sample from a spout or chute does not truly represent the concrete. In the pouring of concrete on a broad surface, such as for a paving base, samples taken near the edge represent too lean a mix, as the coarser aggregate tends to force ahead. With a wet concrete, unless extreme care be taken, considerable mortar is lost in the sampling. There is also a large personal equation to be considered in the ramming of the concrete into the cylinders, and after the cylinders have once been made they are subjected to a wide range of conditions. It must be remembered that the

cylinder has several times the radiating surface of the concrete from which it is taken and is, therefore, subject in a much greater degree to weather conditions. A cylinder is much more easily affected by frost and will dry out in a much shorter time than mass concrete. The cylinders should, therefore, be protected against atmospheric conditions in a moist box, which box should be so constructed as to prevent the cylinders from being disturbed. Where rough, light shanties are constructed on the job, and there is considerable running in and out of the shanties, it is well to cut a hole in the floor and support the moist box from the ground underneath. Cylinders left along the line of the work without protection seldom test up to 1000 pounds. They are not only subject to atmospheric conditions, but are also more or less disturbed and frequently knocked over. The cylinder tests can, therefore, be regarded only as an indication of the strength of the concrete, and it is deemed by the writer to be impractical to accept or reject concrete as a result of these tests. Where the tests consistently run low, it is, of course, an indication that something is wrong with the concrete, and steps should immediately be taken to determine the cause and to rectify conditions. Variations of 100 per cent. in cylinders taken at the same time from the same concrete and subjected to the same conditions are not unusual, and, until the many uncertain factors in the making and handling of the cylinders are eliminated, it does not appear to be feasible to reject concrete as a result of these tests.

MUNICIPAL PRACTICE IN TESTING SAND AND GRAVEL PROPOSED FOR USE IN CONCRETE

By F. W. Lyon*

In the late fall of 1921, the City of Pittsburgh, through the Bureau of Engineering, Department of Public Works, began the making of tests on sand intended for concrete purposes on City work. These early tests were for color only and were but the preliminary steps of carefully recorded colorimetric coal, silt, screen, and compression tests inaugurated on sand in the spring of 1922. Since this time, the Department of Public Works has, through the joint agencies of the Bureau of Engineering and the Bureau of Tests, constantly

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tested all sand used on City work and carefully inspected at the barges gravel intended for the same purpose. In carrying out these tests we have received the cordial co-operation of sand and gravel companies, many of whom, where possible, having assigned bins for the storage of City materials, from which points no deliveries are made except to City work. Where private bins are available, the City makes inspection of only such sand as it proposes using itself, but where City bins are not available inspection is made of all sand delivered, thus giving the independent consumer the benefit of material carefully tested and found suitable to City uses. The requirements to be met and the details of making these tests are either included in the specifications of the City of Pittsburgh, or have been or will be discussed in detail by other papers this evening.

Of course there is only one reason for increasing the scrutiny given concrete materials, and that is the betterment of the concrete or the elimination of possible causes of failure.

Beginning as early as 1916 there was placed in this vicinity, as well as in many other sections of the country, concrete which within a comparatively short time proved to be entirely unsatisfactory, numerous failures of diversified nature being evident from 1918 on. It was quite evident that something was radically wrong with the various components of concrete, or the mixing and placing, or a combination of the two. The question of mixing and placing was one that could be fairly well controlled and kept within the standards of best practice. This was done by the municipality.

There was next the thought of the character of the cement furnished. The various cement manufacturers were possessed, in most cases, of extensive laboratory and technical equipment for the testing of their product. As these tests were presumably being made in accordance with standard practice and the product presumably meeting the requirements of these tests, it was believed that the elimination of cement as a guilty factor was best left to the chemists of the cement companies. Logically carrying through the process of elimination, the next procedure for the engineer of the consumer lay in the careful testing of sand and gravel with a view to determining the presence of unsuitable organic matter or other undesirable conditions in sand or gravel which might be responsible for the failures mentioned.

In instituting and conducting these tests it must not be construed

that officials of the Department of Public Works believed that the cause of concrete failures was necessarily attributable to faulty sand or gravel; but, whether or not these failures actually were caused by unsatisfactory aggregate, it is believed that a test covering the selection of aggregate for concrete is undoubtedly a step in the proper direction, in that it is a fact that the cleaner and more properly graded the sand and gravel, the better will be the finished product. Our purpose in carrying on these tests is not necessarily the accumulation of a vast amount of test data on sand and gravel, but an effort to make sure that this one ingredient is the best that can be obtained. In instituting tests of the nature under discussion, one must begin operations either absolutely in the dark and let experience be the teacher, or else secure such information as may be available from other sources, even though these sources are widely distributed geographically and the physical characteristics of the materials tested are of considerable variance. The City took the latter course and adopted its standards after careful perusal and comparison of data available from other sources. We will all admit, I believe, that, as regards sand deposits and possibility of contamination, the Pittsburgh district is more or less unique. We have the Allegheny River, with a comparatively negligible deposit of coal silt, but with fairly large organic content and with a very considerable sewage outfall to be contended with. On the Monongahela there is much coal silt deposited, with organic matter present and with sewage deposited in close proximity to the sand diggings above the city. On the Ohio there is a conglomeration of the Allegheny and Monongahela River conditions. In setting the standards these various local conditions were considered. In general, we have not yet accumulated data over sufficient duration of time to indicate the wisdom of a change from the standards originally established and still in use.

Relative to the selection of gravel for concrete aggregate, I might say that practically the only test made by the City is that of inspection at the barge and also at the site of the work, for the purpose of determining the presence of improper foreign matter and, in so far as is optically possible, determining that the sizes are within the specified range. It is practically impossible to do more than this without facing extraordinarily high charges for proper and scientifically graded material. At this time, however, I believe it pertinent to urge that engineers especially, and consumers in general, arrive at a definite

conclusion among themselves as to just what they deem necessary or desirable in the way of graded gravel and thereby create a constant and definite demand for these various grades and sizes. In this event it would, I believe, be possible for the producers to install the necessary plant to meet such requirements at a reasonable figure to the consumer. Until this agreement is arrived at and the demand created in sufficient commercial volume to finance the producer's plant, the consumer must necessarily face either what is actually a prohibitive charge for a graded product or be content with the present-day "run-of-mine" material now generally used. I am inclined to believe that the formation of actual working committees from the various local technical societies, fostered by the large consumers and producers, could arrive at very definite results in this respect. In any event the field should undoubtedly be given at least a preliminary survey.

The results obtained to date through the testing of sand and the inspection of gravel by the City are difficult of discussion in terms of increase or decrease in compressive strength obtained over concrete placed prior to the inauguration of tests. It may be said with certainty, however, that the expenditures made for the tests are considered as being well worth while and have had an undoubted beneficial effect upon the resultant concrete.

Without carrying a brief for concrete aggregate, it must be admitted that the results obtained since the using of tested sand and inspected gravel are such as to indicate that some imperfection still exists in the materials of concrete. There being only one other ingredient (with the exception of water) we are constrained to believe that Portland cement as now manufactured does not compare favorably with the grade furnished, let us say, ten years ago. There is no doubt that the cement manufacturers are investigating their product, although as yet they have had remarkably little to say relative to the possibility of the deterioration of present-day cement. It is hoped that through these investigations, and the very emphatic urge of the engineering profession at large, a more satisfactory product will speedily be placed upon the market, or that the manufacturers may place themselves in a position to prove that the fault lies outside the cement itself. A perusal of a recent paper and discussion in the *Proceedings* of the American Society of Civil Engineers, beginning August, 1923,

and ending with December, 1923, dealing with the disintegration of cement in sea water, and with cement in general, will be found enlightening and will amplify the thought just conveyed. I do not wish to digress materially from the subject in hand but, inasmuch as the purity of sand and gravel under discussion is of interest only in so far as concrete is concerned, I am going to take the liberty of quoting three paragraphs from a discussion of the paper just referred to, by Mr. Benjamin A. Howes.* Mr. Howes is a consulting engineer of New York and a member of the American Society of Civil Engineers:

"The use of Portland cement has now had wide scientific study and engineers are in a fair way to use these results in practice. Such studies, however, are now nearly at a dead end, because the manufacture of cement and its constitution has not yet been brought under scientific control. It appears to be widely held that Portland cement is a standard product and that the only study warranted is that of the methods and materials attending its use. Bitter and costly experience, however, has shown quite the contrary; that the products of different mills, and even different runs of the same mill, do not always behave the same under like conditions. . . .

It was not until the work done about ten years ago at the Geo-physical Laboratory of the Carnegie Institution that a real basic explanation of the constitution of Portland cement was furnished. These results were later confirmed by the U. S. Bureau of Standards. From this, it is quite thoroughly shown that Portland cement is a mixture of three distinct hydraulic binders, which act, as far as they are ground sufficiently fine, at different stages of the setting and hardening. There are also some commercial impurities, such as iron oxide, magnesia, etc., that do not affect the functioning of the cement, and some lime sulphate, or gypsum, that retards its setting. These three ingredients are, in the order of their setting or hardening action, tri-calcium-aluminate, tri-calcium-silicate, and di-calcium-silicate.

Errors of manufacture tend first to produce a deficiency of tri-calcium-silicate. This deficiency cannot be determined by chemical analysis, because there is no chemical procedure that will separate the three ingredients. Just to the degree that such deficiency is present, the cement as it hydrates sets free an excess of hydrated lime. To the same degree the resulting mortar or concrete becomes a lime mortar or concrete with a similar drop in permanence under hydraulic exposure."

In conclusion, I might say as regards sand, that in 1922 (the first year of the recorded tests by the City) 15 per cent. of the deliveries were rejected, and, in 1923, 15.4 per cent., as a result of tests made at the floats. For the benefit of the various sand companies I will say that the rejections were fairly evenly distributed.

*V. 49, pp. 1650-1651.

DISCUSSION

Mr. E. V. Braden, *Chairman*:* The subject is now open for discussion. I think Mr. Freeman made an excellent suggestion, and it would be a good thing for this Society in a constructive way to set approximate limits for aggregates so that our local materials may be used economically according as they may be conveniently located near the work. It seems to me that our Society should take that up and come to something very definite along that line.

Now, if you ask your questions promptly, Mr. Reppert will be glad to answer them, I am sure. I see Mr. Wilkerson in the audience. He ought to have information of interest on this subject.

Mr. T. J. Wilkerson:† I have enjoyed very much listening to the paper and written discussions that have been presented and am convinced that they advocate a step in the right direction towards improving the structural quality of concrete. I have for a number of years been hoping that our sand and gravel producers would install crushing plants on their diggers and crush the boulders they now throw back in the river, as the crushed boulders would, in my opinion, make better coarse aggregate than the smooth gravel. I agree with the several previous speakers in regard to increasing the screen for the larger sand size from ¼ inch to ⅜ inch, and the smaller gravel screen to ⅝-inch mesh.

Mr. J. P. Leaf:‡ I think there are two things which should be mentioned. We are wasting a great deal of material which this city will need some of these days. About half the gravel that is handled is thrown back into the river, much to the detriment of the river, and I agree that it should be crushed. It would make better use of the gravel and it would also improve the channel of the river, which is worth something to Pittsburgh.

I have used a test for testing sand quickly on the work. A tube about four feet long and 2½ inches in diameter is filled with water and a sample of the sand, and turned end over end and allowed to settle for four or five minutes. You then have the coarse aggregate

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†Consulting Engineer, Beaver Falls, Pa.
‡City Engineer and Consulting Civil Engineer, Rochester, Pa.

in the bottom and going up until it settles at the top in a fine sand. You can determine roughly whether you ought to go any farther in tests with your sand.

Also, in the matter of cement, we accept cement as all right because the cement man says it comes up to specifications. Yet I know that car-loads and car-loads of gypsum are put into cement by the cement manufacturers, and no matter how little gypsum is in a natural stone it will disintegrate sooner or later. There is a lot of concrete in this Pittsburgh district that in ten or fifteen years will simply go to pieces. For a couple of years it looks all right. We should suspect any cement having gypsum in it—no matter for what purpose. Any gypsum in cement is a detriment to it.

I am very much in favor of using the larger aggregates. The Pittsburgh district has lost thousands and thousands of dollars in the building of our public roads because it has been said that gravel is not fit for aggregate. They want you to use crushed stone. They say these round stones pop out. If you don't keep off the public highways and away from our permanent dams, sky-scrapers and retaining walls, some of these stones will pop out and hit you.

Mr. J. M. Dilley:* In every country, largely as a result of practical experience, there have grown up specifications for Portland cement which, in general, place a maximum limit upon the quantities of non-essential materials which may be present, and prescribe certain minimum physical requirements for the product, in order that it may be deemed satisfactory as an article of commerce, and be relied upon to give results consistent with those of past experience.

The specifications for cement in the United States are now a uniform standard, known as Specification No. 1 of the American Engineering Standards Committee, adopted by the United States government departments and by substantially all engineering societies, and guaranteed by cement manufacturers. There has been in the past so much confusion in defining Portland cement that the American Society for Testing Materials has established a definition which has generally been accepted as describing the finished product. This definition is as follows:

"Portland cement is the product obtained by finely pulverizing

*Field Engineer, Portland Cement Association, Pittsburgh.

clinker produced by calcining to incipient fusion an intimate and properly proportioned mixture of argillaceous and calcareous materials, without the addition of anything subsequent to calcination excepting water and calcined or uncalcined gypsum."

It will be noted that no attempt is made to fix a definite chemical composition for the product, nor to describe the actual materials from which it may be made. This is due to the fact that it is possible to make Portland cement from a variety of materials which are found in various locations in this country. Therefore it was deemed advisable simply to describe the product in such terms as to permit the use of all these materials and then to provide that the finished product should meet the requirements of a standard set of specifications.

Several distinct elements enter into the manufacture of concrete. Portland cement, fine aggregate, coarse aggregate, proportioning, mixing water, mechanical manipulation, human manipulation and curing of finished product.

It has been demonstrated beyond any doubt that, if the cardinal principles of making good concrete are followed out, the proportioning and grading of the aggregates, and consistency, are most important factors. The two elements are so closely related that a change in one necessitates a change in the other if similar results in the finished product are desired. This fact has been established both in theory and practice. The Lewis Institute in Chicago has made up a table giving strengths of concrete for different graded aggregates and, with the other factors remaining constant, there is a great difference in the strength of the finished concrete. In field practice this fact has been proved in numerous instances, a recent example being the method of proportioning concrete used on the Cleveland, Cincinnati, Chicago & St. Louis Railway bridge over the Great Miami River at Sydney, Ohio, as described by J. B. Huntley in the *Engineering News-Record* of October 11, 1923.* The first three of Mr. Huntley's conclusions are as follows:

"1. That the method of designing concrete mixtures, as worked out in the laboratory, is applicable under field conditions, and that a concrete of predetermined strength can be obtained with considerable accuracy by using the proper mix and consistency.

*V. 91, pp. 586-590.

2. That quite dry concrete, of aggregates properly proportioned, can be worked without difficulty and handled by the usual methods, and with considerable saving in cement over that necessary in the wetter mixtures of equal strength.

3. That a specification, simply defining the mix as 1:2:4 and 1:3:6, etc., without establishing some further requirement as to the consistency and grading of the aggregate, means little from the standpoint of strength, as the results may vary 100 per cent., and, consequently, such a specification is uneconomical."

From the viewpoint of the producers of aggregate, the raising in size of the extreme limit of size now permissible will undoubtedly be of economic value, and will permit the making of as good, or better, concrete.

From the standpoint of the engineer, the thing most desired in aggregates is a consistently uniform grading. With knowledge available, and with aggregates running uniform in their grading, it is possible so to proportion and regulate the other elements entering the manufacture of concrete that a finished product of predetermined strength can be obtained.

Mr. F. M. McCullough:* A number of years ago I carried on a series of tests on mortars and concretes made from Allegheny River and Ohio River sands and gravels. These tests are reported in the May, 1915, Proceedings of this Society.† The Ohio River sands were coarser than the Allegheny River sands and gave a stronger mortar and concrete. It would be interesting to know whether other investigators have obtained similar results.

I wish to indorse the statement in regard to the use of coarser sand screens in order to obtain a more desirable sand for concrete. Our students reguarly test Pittsburgh sands and a very coarse, well-graded Chicago sand, and we find that 1:3 Chicago sand mortars have about 100 per cent. greater strength than local sand mortars. One year we made up two sets of 1:2:4 concrete cylinders, using Allegheny River gravel in both sets; but Allegheny River sand in one set and Chicago sand in the other. The set in which the Chicago sand was used gave 25 to 30 per cent. greater strength.

In our laboratory tests we have also found that Allegheny River sand gives a rather dark color in the colorimetric test, particularly if

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†V. 31, pp. 334-367.

the solution stands longer than 24 hours. This color often is so dark that the sand would ordinarily be rejected, and yet the strength test is usually quite satisfactory. Unquestionably, the colorimetric test can not be interpreted so strictly when coal or lignite is present.

In my opinion, a very profitable field of investigation would be a study of the proportioning of concrete mixes. A 1:2:4 concrete may or may not be as strong as a 1:1:5. I think it would be very interesting to check the Abrams tables with Pittsburgh sands and gravels, and I hope some scheme of co-operation can be worked out so that this study will be made.

Mr. C. N. Haggart:* I have been very much interested in the first part of the discussion as to control in the making of concrete. I think the subject is very important, and particularly so to engineers designing smaller buildings of reinforced concrete where inspection and control are not ordinarily obtained. A great deal of my work is along the line of designing buildings of concrete and steel, and I find it very difficult to get proper construction in concrete. In large construction work it is comparatively easy to get appropriations for proper inspection; but in small work, which may be structurally important—an office building or other reinforced concrete structure, where high tensile stresses are used—it is very important to get good concrete. It is often difficult to get the owner to see the necessity for inspecting the material and the manufacture of the material. I think that is one place where it is the duty of the engineer to educate the man who spends the money.

I had an experience over a year ago where the owner undertook to construct important foundation work which I had designed. There was to be no inspection on it, but I managed to scare him a little. Among other things, I told him he would have to make the colorimetric test on the sand to know that it was all right, and in that way I obtained a little assurance that we were getting a good grade of concrete. After that I went up and looked at the work superficially, and I believe we obtained good concrete.

In another case where I designed some structural work the question came up as to whether I would allow the use of slag instead of gravel. In cases like these the owner or contractor does not usually

*Structural Engineer, Pittsburgh.

care to go to the expense of having you go to the place where the material is obtained and make an inspection. In this particular case I wrote a letter stating the conditions under which slag aggregate might be used, but they afterwards used gravel. Later on I had occasion to go to the site and found that some of the gravel they were using had a very considerable amount of flat and elongated pieces, which I did not consider very good for the concrete. This gravel was to be used in the floor, however, and I allowed it to pass. I mention this simply to show the difficulty we may have who design smaller structures which are structurally important.

I am interested in increasing the maximum size of sand, and I see no reason why we should not take some step to-night toward the use of a higher maximum in the size of grains of sand to be used in this district. I would, therefore, make a motion that the Chairman appoint a committee of three, who will investigate and report to this Section the advisability of recommending the use of sand with higher limits for the large grains. I realize that it is not a very simple matter to change the standard size of sand used in this community. It may be comparatively easy to convince engineers that it is desirable to make this change, but the greater portion of the sand that is sold in the city is sold to owners or contractors who do not have technical advice and who have become accustomed to the use of ¼-inch sand, and it would be necessary to do a little educational work to get these men to accept the ⅜-inch sand. But I believe we should investigate this matter and, if it is found that a better concrete can be made, we should, through the material men, demonstrate to the trade and the people who use this sand that ⅜-inch is better than ¼-inch sand. Thereby we would be helping the trade and all those who have need for concrete construction.

Mr. P. W. Price:* With the consent of the maker of this motion, I would like to amend it to cover the whole question of concrete aggregates, to include a study with recommendations along the line so clearly indicated to-night. Points brought out in the papers this evening, and their discussion, would indicate the desirability of the Society taking some action applicable to the conditions met in the Pittsburgh district. If these recommendations were conservative and,

*Assistant Engineer, Allegheny County Engineer's Office, Pittsburgh.

at the start, had the indorsement of large users of concrete, and were concurred in as far as possible by large producers of sand and gravel, it would seem that this meeting would have accomplished something well worth while. This would be better than to allow this information to remain more or less buried in the PROCEEDINGS of this Society. It is always more difficult to accomplish the results we all hope for if the matter be left entirely to individual effort.

MR. E. V. BRADEN: That could be done by enlarging the committee so that it can make a complete study of the subject, with a view to submitting recommendations for specifications for general use. We do not want to give the committee such a big job that we will never get the answer. That is, however, for the meeting to determine. I think that this is a matter which should come before the Board of Direction, and the Chairman would like to have the authority to submit the proposed membership of the committee to the Board for its approval.

Mr. Dann, have you anything to add?

MR. A. W. DANN: Nothing, except a word regarding the production of coarser sand. As conditions exist at the present time it is hard to produce coarser sand economically. There is not enough demand for it and it means a continual changing of screens. I think the engineers will be able to obtain a good deal better concrete by the use of this coarser sand and gravel.

MR. JOSEPH S. LAMBIE:* The proposed adoption of a higher maximum size for sand grains will unquestionably work radical changes in the commercial and engineering aspects of our problem, but I doubt very much whether any material benefit will be derived thereby. It has been said that a ⅜-inch sand will test higher than a ¼-inch sand. It will, for the reason that a percentage of coarse aggregate has replaced an equal percentage of sand, and the former is the stronger material. The real sand sizes effective in combining with the cement to form mortar lie between the No. 14 and No. 48 screens. Anything coarser should properly be classed with the coarse aggregate as far as its effect on the mix is concerned.

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The effect of a ⅜-inch sand when combined with coarse aggregate to make concrete is entirely different from its effect when used alone in a mortar mix. In order to obtain strength equal to that obtained from a ¼-inch sand, it will be found necessary to increase the amount of sand in the mix from 15 to 50 per cent. and make a proportionate deduction from the coarse aggregate. You can verify this if you wish by referring to the Abrams tables of concrete mixes. The reason advanced for increasing the size was that it would furnish a more adequate supply; but, if more of it is required to obtain equivalent results, the purpose will obviously be defeated. Exactly the same results can be obtained by continuing to use ¼-inch sand, but reducing the amount.

I do not believe that sufficient attention has been paid to the qualities of the coarse aggregate. Speaking specifically of the local gravels, I have found that a strong mortar will not always give a strong concrete. A good mortar should develop sufficient strength in 6- by 12-inch cylinders to fracture the coarse aggregate in a compressive test. In quite a number of cylinders which I have recently tested the mortar broke away like a shell from around the gravel, and at loads far below those that the mortar was capable of developing. The exposed gravel and concavities in the tested specimen were covered with a fine powdery film which had prevented the proper bonding of the mortar with the gravel. I believe that, relatively, the gravel in this district is not as clean as the sand. While there is no official colorimetric test for gravel, I have recently been applying it, under identical conditions, to local sand and gravel obtained from the same source. Where the sand ran 1 and 2 on the usual color chart, the gravel generally ran 2 and 3. If the gravel were thoroughly cleaned, there would be none of the "popping out" to which a previous speaker referred.

Mr. P. W. Price: I have had a similar experience. Suspecting that the colorimetric test might show up badly in the coarser aggregates, I separated a sand sample to be tested into two parts by use of a 1/16-inch screen. This sand had the appearance of being clean and sharp, and it did not contain an undue amount of coal. I found that about 25 per cent. was retained on this screen, and it consisted mainly of fine white quartz pebbles. The results of the color tests were as follows:

Fine particles, passing a 1/16-inch screen, tested No. 2.

Coarse particles, retained on a 1/16-inch screen, tested No. 4.

Unscreened sand, containing particles ¼ inch in size, tested No. 3.

The above results would indicate that it would be well to make similar tests of gravel. Average gravel received by us contains a considerable amount of fine pebbles running in size from ⅛ to about ⅝ inch. These would very likely show No. 4 for the color test if received from the same locality as the sand noted above. It is thus indicated that, in some cases at least, a greater percentage of humus matter is to be found in the coarser parts of local concrete aggregates.

Mr. C. S. Davis:* I would like to ask Mr. Freeman if the same results could not be accomplished by proportioning the fine and coarse aggregates in accordance with Abrams' "fineness modulus of aggregate." Would not the actual amount of aggregate, as determined by each sieve, with the fine aggregate graded from ⅜ inch down, be the same as with the fine aggregate graded ¼ inch down?

Mr. P. J. Freeman: I have been recommending that change in the size of the sand with two principal ideas in mind. One is to follow the general tendency of the national societies and highway departments in raising the upper limit for sand size. The tentative specification of the American Society for Testing Materials covering concrete aggregates (C 33-23 T) uses the ⅜-inch sieve as the upper limit, and this is also the requirement of the Pennsylvania State Highway Department.

The second reason applies particularly to conditions as they exist in this district, as the proportion of sand to gravel is very much lower than in many other places. In New York we would not have this reason, as they have more sand than gravel. If we push up the size of the sand we raise the strength of the mortar and also increase the quantity of sand available in this district. Without sand the slag people can not sell slag and the limestone people can not sell limestone for concrete.

We can by careful proportioning of the aggregates get the same results as to strength in the concrete if we try hard enough, but we

*Consulting Engineer, Pittsburgh.

still overlook the economic advantages of getting more natural sand in this district. In thinking of sand sizes it is a very common error to assume that a No. 4 sieve has ¼-inch openings when it is really only about 3/16 inch. In actual practice the ⅜-inch sand will be only a trifle coarser than ¼ inch in its greatest dimension.

Mr. C. S. Davis: If the aggregate should be proportioned by Abrams' "fineness modulus" instead of by fixed parts of fine and coarse aggregate, and if this should result in the use of less fine aggregate, the natural result would be in the interest of economy. I can not see that changing the sand screeens will have any effect upon the relative amount of fine and coarse aggregate used, if concrete is to be made of maximum strength. I am not opposed to making the change in grading proposed by Mr. Freeman, but believe that greater economy will result from using larger coarse aggregate.

Mr. Joseph S. Lambie: It has been my experience that for slag and broken stone concretes a finer sand than that used with gravel is necessary in order to secure proper workability without the addition of excess water and also to secure a better bond on the rougher surfaces.

CONCRETE PILES AND CONCRETE PILING CONSTRUCTION*

By Maxwell M. Upson†

It is the purpose of this paper to give a brief résumé of the concrete pile industry and development in the United States during the last twenty years.

The concrete pile is a child of cheap cement. It was not until the late 'nineties (when the cost of cement began to decline) that the inventive minds of America and Europe turned their attention to the substitution of concrete for wood in this long-used method of foundation construction. In this age, which may, by future historians, be well termed the "Cement Era," we see concrete or reinforced concrete substituted for almost all structural purposes. It is therefore natural and logical that the concrete pile should introduce itself in the very beginning of the reinforced concrete period of development.

In the United States this branch of industry has classified itself into two distinct schools—(1) the cast-in-place type of pile; (2) the precast reinforced concrete pile. These have both found their positions in the engineering world because they give to the user one or more of the following advantages:

1. Unquestioned permanency.
2. Reduced cost.
3. Saving in time.
4. Structural capabilities which exceed those attained by other foundation units.

Engineering has three great objects—first, the production of an adequate structure or machine, capable of safely doing the thing for which it is designed; second, its production at the lowest possible cost; third, its accomplishment in the shortest possible time. It is lamentably true that the last two desiderata are not accorded the attention they warrant. Given enough money, any engineer can build almost any structure. It is only a genius who can produce that which is desired at minimum cost and in minimum time.

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†Vice-President and General Manager, Raymond Concrete Pile Co., New York.

In this commercial age it is perhaps because of the desire of the engineer to meet the last two requirements that the concrete pile has found its way into commercial use. There is, of course, a very close relationship in the ultimate answer between saving in cost and saving in time. In the character of construction considered in this paper—foundations, piers, bulkheads, caissons, etc.—not infrequently conditions are encountered where the saving in time in the accomplishment of work may, in dollars and cents, almost pay the total cost of that portion of construction. This answer comes largely through the interest on the money invested and the earning power of the completed enterprise.

As previously stated, the two systems of concrete pile—namely, cast-in-place and reinforced precast—have found their different fields largely on the basis of their commercial relationships.

The precast pile, which was first used in Europe in the late 'nineties, consists of concrete and steel combined in a manner that can be formed into a shape which makes it possible to substitute it in the place of the well known and long used wooden pile. It does not seem necessary to discuss this at any great length, for the reason that it is now a well recognized and well understood unit, which occupies an important position in certain types of structure. It may, however, be well to enumerate its advantages and disadvantages so that its engineering status may be determined.

Because of the generally acknowledged tendency of concrete to deteriorate when poured so that setting takes place between high and low water, it is the best engineering practice to use precast piles on water or sea constructions. This method affords an opportunity for the pile to cure and obtain its maximum density and hardness before it is subjected to alternate wind and water action. For the last twenty years there has been a very serious and well founded debate among engineers as to whether concrete, even precast and properly cured, can be made to resist certain sea-water action. This debate has been brought about largely by the many evidences of structures which have deteriorated or collapsed under the action of salt water. However, very careful analyses of all these failures or weaknesses have disclosed that in practically every instance improper methods or materials have been used. It was not until the last four or five years that engineers realized that for this service rich mixtures of concrete

must be used. These mixtures may be varied to suit different materials, but, in general, should not be weaker than one part cement, one and a half parts sand, and an aggregate proportioned to make the greatest density. One of our technical societies recently made a canvass of the chief engineers of the principal railroads and harbor cities of the United States, making inquiry for a record of their troubles in the use of concrete in sea-water, and asking whether in their opinion there is any danger in subjecting concrete, when properly placed, to sea-water action. This canvass resulted in practically 100 per cent. approval. Many of these men have had trouble from this source, but in the light of the developments in the art in the last ten years, have ample proof of the sufficiency of this type of construction when properly designed and built.

To illustrate an earlier statement that the capabilities of a concrete pile are beyond those of other structural units, attention is drawn to an outfitting pier designed and built for the Sparrows Point plant of the Bethlehem Steel Company. In order to operate the floating dry-dock which is fastened to this pier, a depth of 50 feet of water was required. The supporting of the heavy concentrated loads demanded by large-capacity cantilever cranes could not be effected by wood piles because of very great unsupported lengths; neither could caissons be substituted (unless piles were placed thereunder), for the reason that the underlying soil was not suitable for heavy loading. Here a reinforced concrete pile of large cross-section proved a safe and economical unit which in every way fulfilled the requirements.

For foundation use, a number of different types of reinforced concrete piles have been developed, many of them having some patented features.

The Giant Pile. This type, shown in Fig. 1, is patented and operated by the Giant Concrete Pile Company, of New York. The patented feature lies chiefly in the method of driving. A cast-steel point is built integrally with the concrete of the pile, the reinforcing bars being fastened thereto. The upper flanges of this point project beyond the faces of the concrete pile, forming a shoulder on which rests a driving frame, consisting of two steel channels. These channels extend the entire length of the pile and, through the medium of a specially designed head, the entire force of the hammer blow is

transmitted directly to the cast-steel shoe. This protects the concrete from the abuse and the stress of driving. When the piles are driven the channel-iron frames are withdrawn, to be used again on the next pile. The space left in the ground when the frame is withdrawn must be filled by the closing in of the soil against the surface of the concrete pile. This arrangement permits of very severe driving without endangering the integrity of the pile itself.

It is obvious that this type of pile is suited chiefly to point-bearing ground, since the removal of the frame eliminates the friction, which in most piling is an important factor in the carrying capacity of the unit.

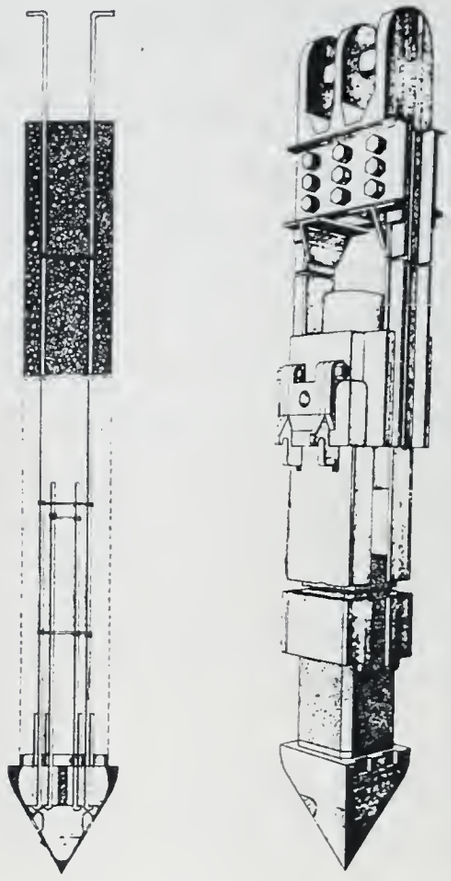

Fig. 1. Giant Pile.

The Bignall Pile. This design (Fig. 2), named after its patentee, is owned by the Bignall Piling Company, of Lincoln, Neb. The patentable features consist of a multiple jetting system. A large jet pipe extends longitudinally through the center of the pile, being reduced at the point to about a 1⅛-inch orifice. At frequent intervals the longitudinal pipe is tapped and connected by ¾-inch nipples with the four outer faces of the pile. These nipples are turned upward by means of a right-angle elbow. In placing the pile, a two-inch jet pipe is inserted inside the large pipe in the center so that two separate

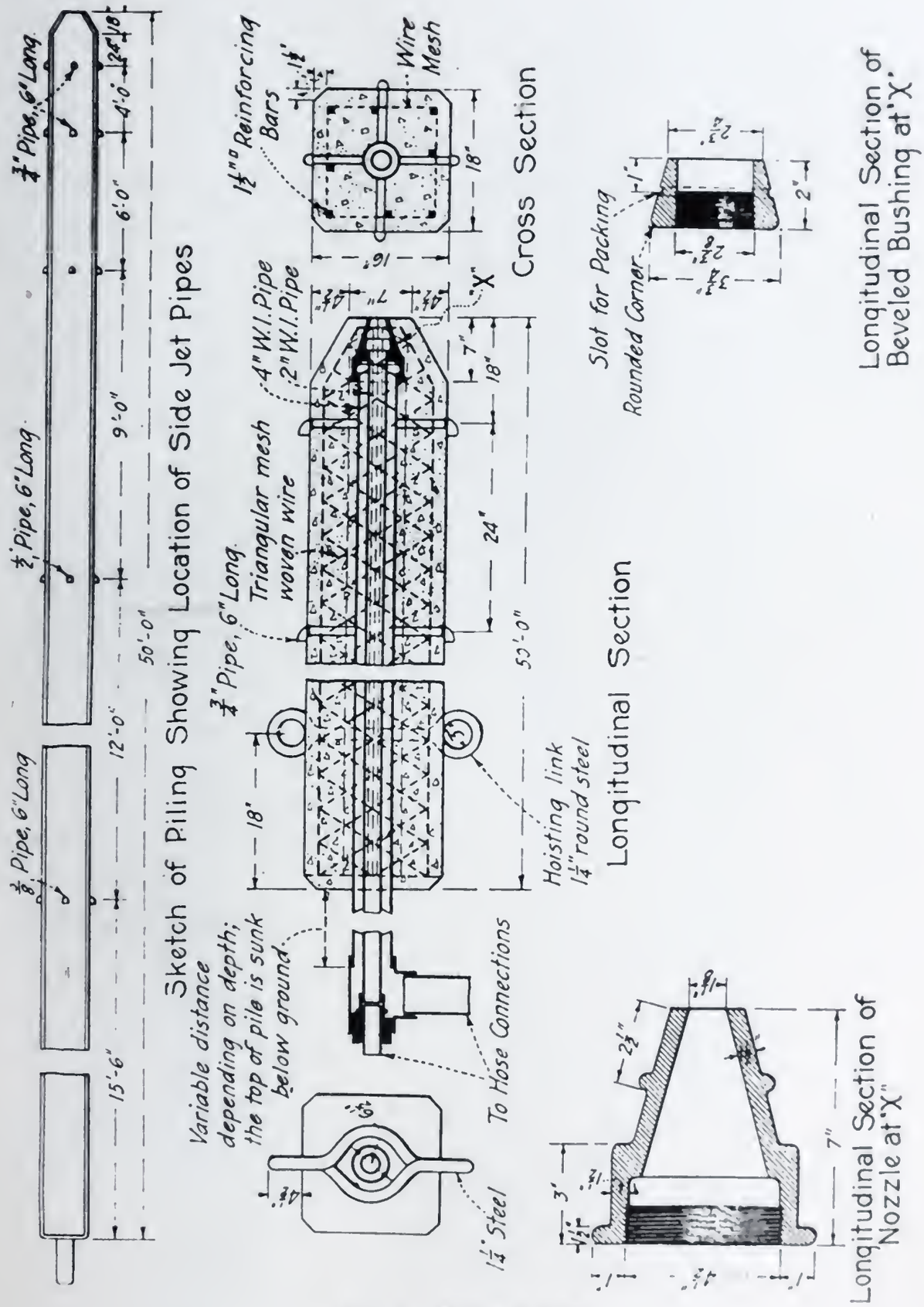

Fig. 2. Bignall Pile.

jetting processes are carried on simultaneously. A two-inch pipe operated under a higher pressure delivers a jet stream in the usual way at the point of the pile, while the various ¾-inch connections

permit water at a lower pressure to escape upward along the face of the pile, thereby tending to destroy all frictional resistance and permitting the pile to sink in place by its own weight. This type of pile is usually handled by a derrick or crane; no pile driver leads are deemed necessary.

Obviously, this pile is suited to soils which can be penetrated by a jet. There is, however, some question of the effectiveness of the jetting method alone in many materials, such as clay, gravel, or hard-pan.

Both the Giant and Bignall piles are designed essentially for foundation purposes and, so far as the writer knows, have never been applied to water or pier construction. However, it is for work in water that the precast pile has found its largest field.

As previously indicated, experience has shown that concrete is not permanent when cast in place between high and low water. The alternate saturation and drying seem to increase its permeability, which naturally opens it to the destructive action of chemicals and frost. On the other hand, proper curing of a dense or impermeable concrete before being subjected to this action gives a material that is permanent and will withstand all ordinary exposures to sea-water or frost. The reinforcement so essential in precast piles is naturally needed for the column strength in water construction. These two features of this particular type of pile are, consequently, responsible for its almost exclusive use in wharf and pier construction. For foundations, however, it has marked and obvious weaknesses, which may be enumerated as follows:

1. Time lost in casting and curing prior to driving.

2. Impossibility of predetermining exact length, resulting in wastage or expensive splicing.

3. Excess cost due to the handling and transporting of heavy weights and the providing of an excessive amount of steel in order to reinforce sufficiently to permit handling and driving.

4. Unsuitability for hard driving.

5. Cost of jetting, and consequent cost of handling water required in jetting.

It is because of the above that the American engineer early devised what is termed the "cast-in-place" concrete pile. This type of pile is divided into two distinct classes—(1) that having a shell which

Fig. 3. Raymond Pile.

remains permanently in the ground, providing a form for the concrete; and (2) that which provides a hole in the ground and permits the green concrete to come in contact with the adjacent soil. The first class is illustrated in Fig. 3 (a Raymond pile, partly filled with concrete and showing the shell), and the second by Fig. 4 (a Simplex pile, partly filled with concrete and showing the driving pipe).

Steel Piles. Another type of pile using a shell which has come into use within the last fifteen or twenty years is known as the "steel pile." This method seems to have originated under a patent taken out by Jules Brechaud in 1896 wherein he utilizes the weight of the structure to jack these piles into the ground. This process consists of cutting a narrow vertical recess in the masonry of the building

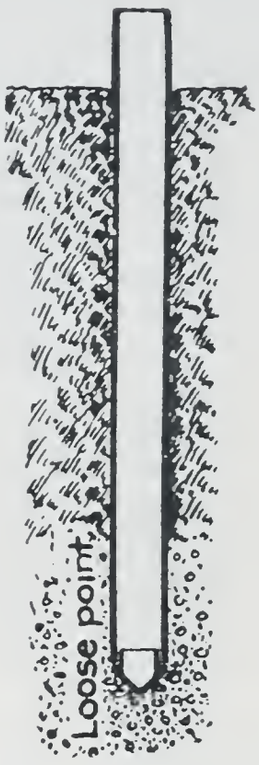

Fig. 4. Simplex Pile. Form Driven into Hard-Pan.

wall and inserting in this a short section of steel tubing, from 12 to 18 inches in diameter. This is forced vertically into the ground by means of hydraulic jacks of from 60 to 100 tons capacity, reacting against short horizontal girders built into the masonry above. Each section of this pipe (usually of extra heavy weight) is coupled to the next in a manner that extends the length of the tube until it finally attains sufficient resistance to carry the determined load. The earth is then washed from the interior of the tube, the bottom is sealed, and concrete is deposited until the pipe is filled. Bearing plates are used at the top of the pipe to carry the load of the building. This method

is necessarily slow, giving a progress of not over 8 or 10 linear feet of piling per day.

From this system developed the use of driving steel piles, usually to rock, for new building foundations. None of the methods of placing this pile, so far as the writer knows, is patented. A pipe is usually driven into position by means of a hammer or jet, each successive section fitting to the next by means of interior sleeves or joints. When rock is encountered, the tubes are emptied, either by compressed air or water, the bottom sealed, and the pipes filled with concrete. The New York building code originally allowed a loading based on 5000 pounds working stress on the steel and 500 pounds on the concrete. In order to increase the loading, reinforcing bars were used. A later ruling on the part of the city authorities has limited the loading of the steel to the annular area, less ⅛ inch allowance for rust, plus 500 pounds per square inch of concrete section. No reinforcing steel is permitted. The tubes employed for this purpose vary from 10 to 16 inches in diameter and are usually from ⅜ to ½ inch in thickness.

Several patents have been taken out covering the sleeves or joint members, as this detail of construction is of importance because of the necessity of transferring the load from one section of steel pipe to the next.

This type of pile has not been generally favored by engineers for the reason that its life depends on the permanency of the exposed steel. If the ground carries no seepage of acid or other chemicals which are destructive to steel, it would seem that the pile ought to last for an indefinite period. Most soils exclude from the adjacent steel the oxygen which is usually essential to the rusting process.

The Pretest Pile. A variation in the use of pipe piles for underpinning has been developed in New York under the above name. This system involves the placing of footings of a new building on short sections of steel piles superimposed by hydraulic jacks. As the weight of the building increases, the jacks are used to force the sections of piling down so that the elevation of the footing is maintained at the same grade. The theory of the inventor is that the actual load tests the pile while it is being put in place, and therefore assures the engineer that the foundation is adequate for the load.

The Raymond System. The pile which is formed by (1) driving a collapsible mandrel encased in a sheet-steel shell; (2) withdrawing the mandrel after sufficient penetration has been secured, leaving the sheet-steel shell in the ground to serve as a form for the concrete; and (3) filling this with concrete, is known as the Raymond type. This was first developed and patented in the United States. The inventor, Alfred A. Raymond, was a bridge builder and practical pile-driving man. While engaged in building railroads and repairing bridges in Kansas and Nebraska in the late 'nineties, he was impressed with the short life of timber piles in the construction of trestles. It was in an attempt to secure a substructure of a permanency equivalent to that of the masonry superstructure that he devised the Raymond system of concrete piling.

The first piles of this type were driven by Mr. Raymond in the foundation of a Chicago apartment house in 1901. This work caused considerable comment in the engineering world, but it was generally believed that this field for concrete was exceedingly limited and that the business would never develop to any great magnitude. On that account, it was some years later before Mr. Raymond was able to enlist sufficient capital to promote his ideas adequately.

It is of interest to observe that millions of feet of concrete piling are now driven annually. The Raymond Concrete Pile Company alone drives a lineal footage which represents a timber saving of more than three thousand acres of heavy growth of timber per year. This information should stir the enthusiasm of those who are promoting forest preservation.

In order to illustrate this system more in detail, drawings outlining the principles are shown. Fig. 5 represents the Raymond system. It will be noted that the collapsible mandrel has been removed from the steel-lined hole. The shell serves the triple purpose of preventing the admixture of water and material with the concrete, of maintaining the shape and size of the core so that the hole can be carefully inspected before the concrete is placed, and of sustaining the pressure against the earth which has been attained through the driving of the mandrel. It should be observed that the core or collapsible mandrel is built with a substantial taper. Mr. Raymond found in his wooden pile work that there seemed to be a marked increase in the carrying capacity of the pile which has the greater

taper. On that account, he designed his first cores with a taper materially in excess of that which may be found in the natural growth of timber. It is interesting to know that this observation has been demonstrated as correct, both theoretically and practically, to a degree not appreciated at the time of its adoption. A discussion of this will follow.

The shell is made of sheet steel, spirally reinforced with a heavy wire. The providing of an adequate and economical shell of sufficient

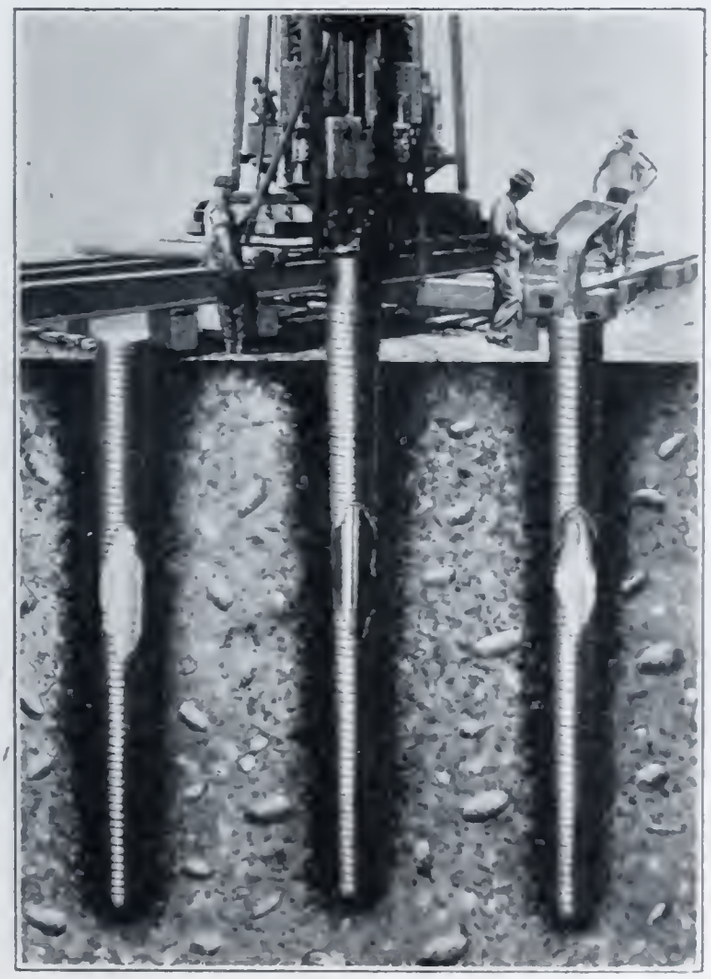

Fig. 5. Raymond System.

strength to withstand the back-pressure of ground of an elastic nature was the most difficult problem in the perfecting of this system of pile. When making these shells out of plain steel, it was found that, while 20-gage (B.w.g.) metal might successfully resist the pressure in certain soils, 14 or 12 gage was required in other soils. Furthermore, it was impossible to predetermine the pressure to be encountered, and, in consequence, almost impossible to estimate the cost of the shell for any specific piece of work. The spiral shell, as described above, com-

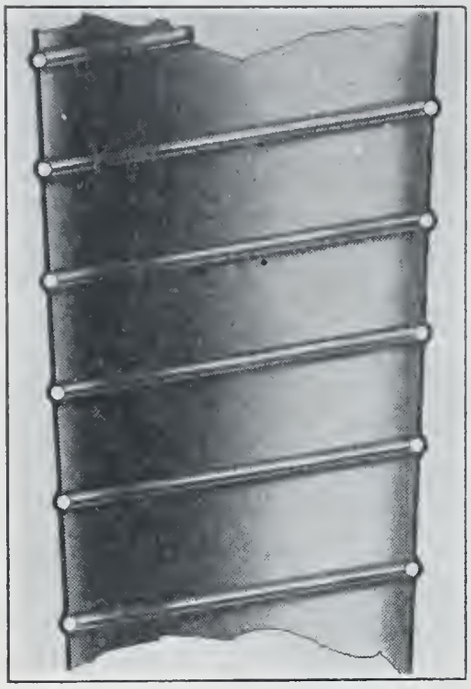

Fig. 6. Raymond System. Steel Shell Corrugated around Wire Reinforcement.

Fig. 7. Raymond System. Winding of Wire on Collapsible Mandrel.

pletely solves this problem in that it gives the strength of a 12-gage plain shell with a weight of metal equivalent to a 20-gage plain shell. The spiral wire extending the entire length of the finished pile also provides a reinforcement which is advantageous to all types of concrete column construction.

It will be observed by a close examination of Fig. 6 that the sheet metal of the shell is corrugated around the spiral reinforcement. This serves the double purpose of holding the reinforcement in place and stiffening the shell. Special machines are used in the making of these shells. Fig. 7 shows the winding of the wire on the collapsible mandrel; Fig. 8 shows the placing of a plain shell over this mandrel; and Fig. 9 shows the corrugating of the sheet metal around the spiral wire. These shells are made in eight-foot sections which telescope into one another, forming a continuous rigid steel form. They are manufactured in a sheet-metal working plant and shipped to the construction job. Because of their taper, it is possible to telescope them

into one another, thereby increasing the ratio of weight to volume so that minimum car-load capacities can be obtained.

One of the advantages of the sectional type of shell is the convenience with which the length of the pile can be varied. If longer piles are encountered, additional shells are placed on the core; if shorter, the top sections may be removed at the same time that the core is collapsed.

Fig. 8. Raymond System.
Placing of Plain Steel Shell over Mandrel.

Fig. 9. Raymond System.
Corrugating of Shell around Wire.

Some of the features of the collapsible core used by the Raymond Company in the driving of these shells are ingenious and novel. One of the greatest problems encountered was the building of a workable collapsible core. Because of the excessive pressures produced in driving, a locking of the metal is apt to occur between the beveled centerpiece and the three external segments. This is overcome by lifting the false leads from the core after releasing the two latches. This operates three center cams which use the outside plates as a fulcrum for lifting the centerpiece with its series of wedges which hold the plates in the expanded position. Prior to the development of this

mechanism, it was not unusual, in attempting to collapse the core in soft ground, to lift out the shell with the core uncollapsed.

Features of this type of pile which appeal to engineers are as follows:

1. A permanent shell which remains in the ground, thereby providing a continuous pile which may be inspected prior to filling, to insure a perfect column.

2. The maintaining of the compression of the earth which is attained by the penetration of the pile into the ground. This mate-

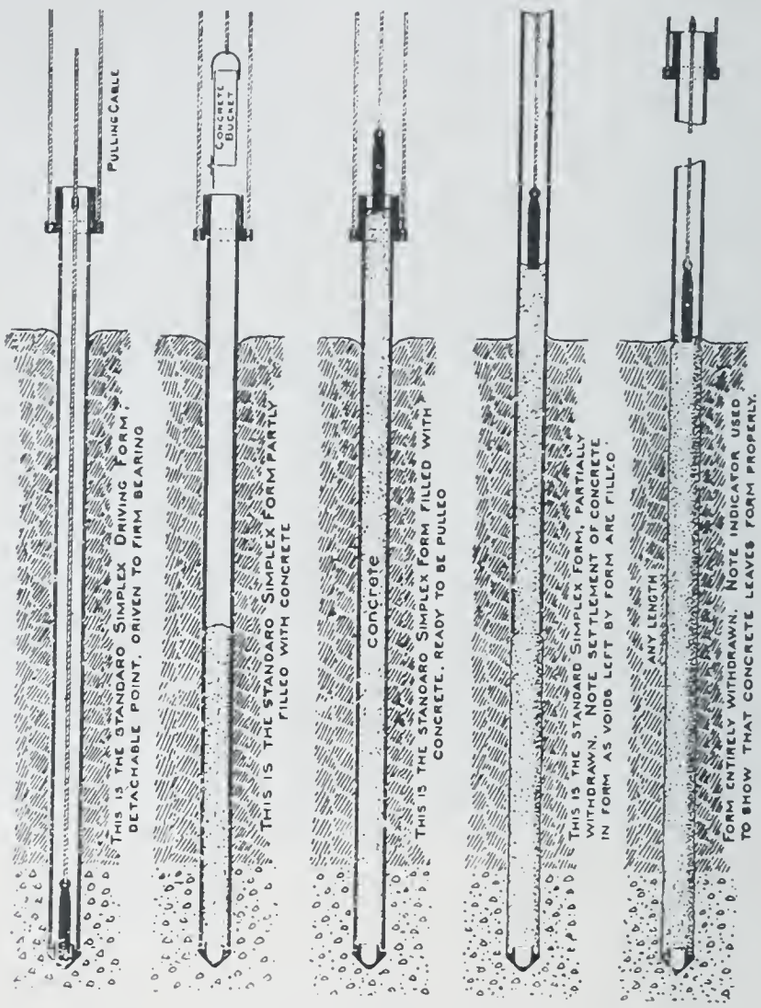

Fig. 10. Simplex System.

rially increases the unit surface friction, and consequently the carrying power, of the pile. In uniform ground this means a reduction in length for the same loading.

3. The rigidity of the shell prevents distorting the pile by the driving of adjacent piles while the concrete is "green."

The Simplex System. In 1903, a contractor in Washington, D. C., devised a means of placing concrete piles which later resulted in what is known as the Simplex system. It was a question as to who

the real inventor was, and the matter was settled only through litigation in the United States courts covering a period of six or eight years. The courts eventually held the inventor to be Richard J. Beale.

This pile (Fig. 10) is formed by (1) driving a pipe having a cap or protective point; (2) filling the pipe after sufficient penetration has been secured; and (3) withdrawing the pipe in a manner that will allow the concrete to fill the hole which is left by the withdrawal.

It will be observed that a bottom dump bucket is used to fill the pile and that the concrete is rammed or held down by a heavy weight when the shell is being withdrawn. Another method of attaining

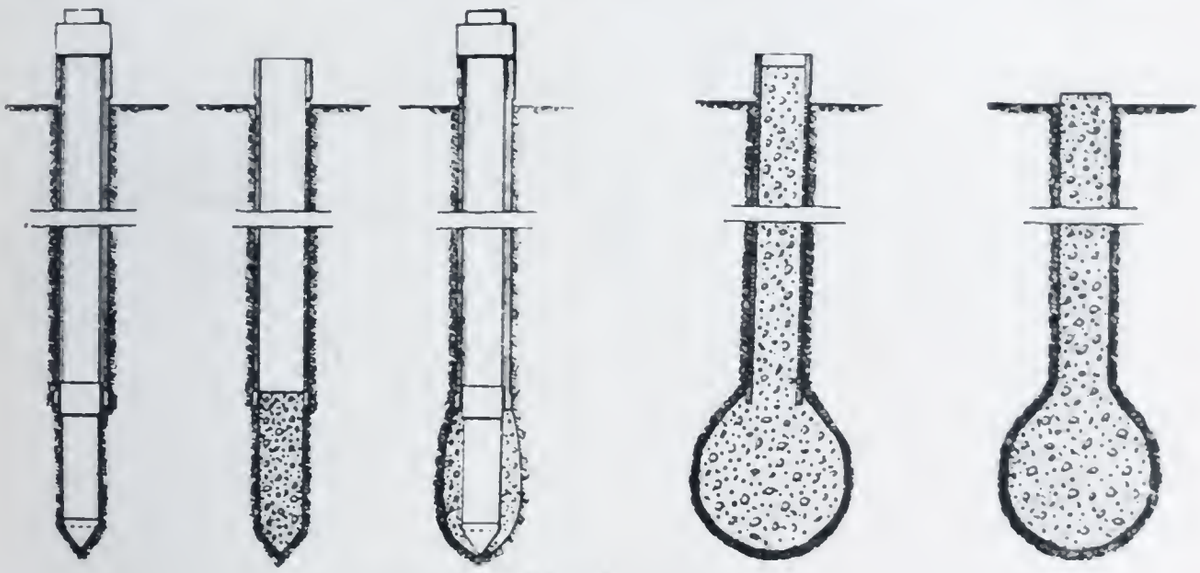

Fig. 11. MacArthur System.

this same end makes use of an "alligator" point instead of the metal cap or point previously shown. The process of filling the pile is the same except that the pipe is raised slightly prior to filling the hole with concrete and a heavy weight is dropped into the interior to force the "alligator" jaws open so that the concrete may be poured into the hole beyond.

The MacArthur System. Still another method of accomplishing practically the same end has been devised and patented in the United States. This is known as the "Abbott" or "Pedestal" pile (Fig. 11), now operated under the name of the MacArthur Pile & Foundation Company. This was invented by Mr. Hunley Abbott. It consists of driving a pipe or casing having an interior core which projects several feet below its end. The theory of the pile is that the penetra-

tion is secured to hard-pan or a substantial stratum upon which rests the point of the core. The enlargement at the base of the pile is formed by ramming the concrete into the opening left by the removal of the projecting core before the pipe itself is pulled up. The method of filling and withdrawing the pipe after the base has been formed is similar to that of the Simplex system except that the interior core usually rests on the "green" concrete while the outside shell is being removed.

The Compressol Pile. This type is clearly a concrete caisson, since it is usually placed in a large cross-sectional area. It is the only system of cast-in-place pile that has been developed and used in

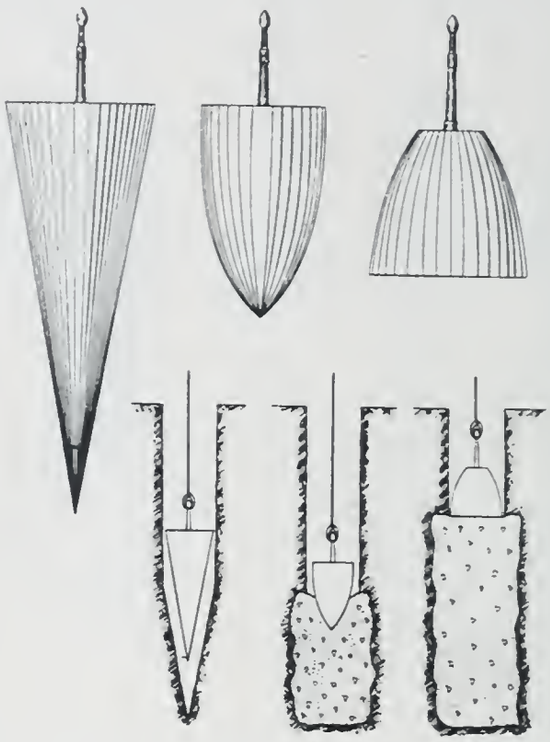

Fig. 12. Compressol Pile. Method of Construction.

Europe. The methods of operation are fairly well illustrated in Fig. 12. A very large and heavy plumb-bob type of casting is lifted and dropped repeatedly into the earth until penetration is secured to substantial underlying material. If the character of the ground is not plastic enough to maintain the walls, clay is added so that the travel of the falling unit lines the hole with the clay surface. The hole is then filled with concrete and again rammed with instruments of different shapes.

This system of piling has not gained favor in the United States, largely because of the inevitable factor of uncertainty in determining what is the real carrying power of a unit so placed.

The Gow Pile. A caisson or large pile construction which is favorably known in this country, and which has been used largely in New England, has been patented and promoted by Charles R. Gow, of Boston. It is really an excavated caisson. Fig. 13 shows a series of telescoping steel cylinders which are driven in advance of the excacator, thereby forming a tight and convenient sheeting. This sheeting may be driven through a stratum of quicksand or water-bearing material so that the water is entirely cut off, thereby permitting hand excavation. When a substantial underlying stratum is reached, the hole is belled out to give the desired unit compression. Where good

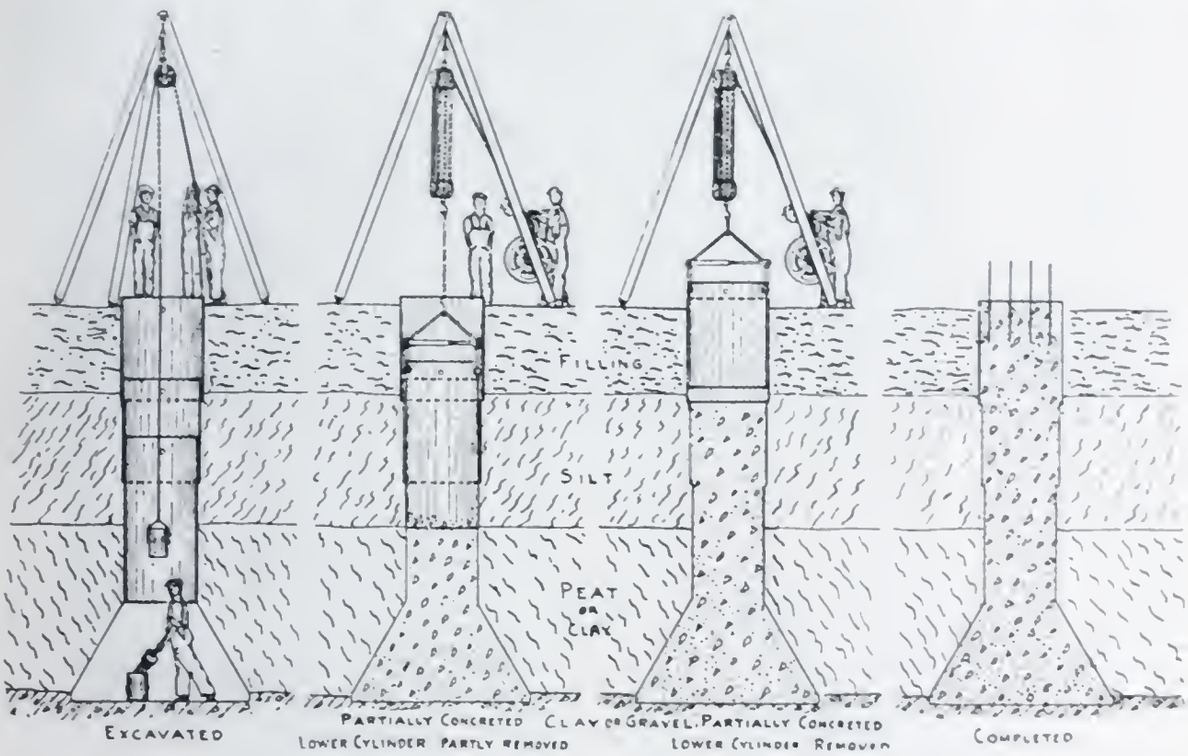

Fig. 13. Gow Pile.

substrata are obtained, and loads are heavy so that the bearing value of the large unit may be utilized, this type of foundation proves economical and speedy of construction.

In water-bearing soil where the sheeting cannot keep out of the water, a modification of this method is employed. This is illustrated in Fig. 14. The essential features of this system, which is patented, are the providing of a large working chamber for air excavation and the use of the excavated materials to add to the weight and remove the friction so that the reinforced concrete unit will travel down without the use of additional loading methods to overcome the working-chamber air pressure. This type of caisson provides a low

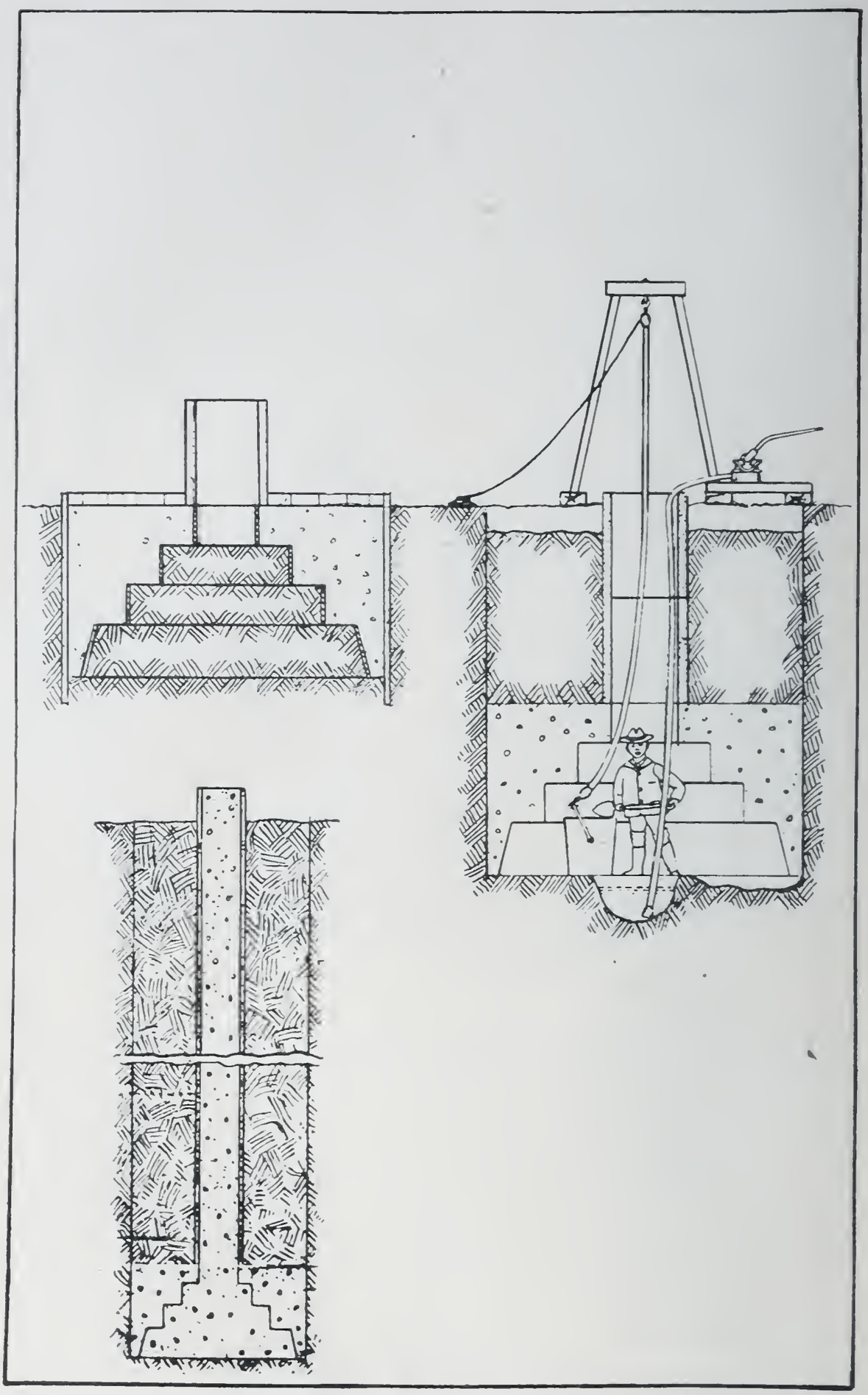

Fig. 14. Gow Pile. Modification for Wet Soil.

working stress for the underlying subsoil and a minimum amount of concrete in the caisson which carries the load to the surface of the ground.

Raymond Composite Piles. A rather new development which has been promoted by the Raymond Concrete Pile Company during the last six years is known as the "composite pile." It is illustrated in Fig. 15. Its use has developed very largely in locations where material is so soft that the friction pile is not feasible and it is conse-

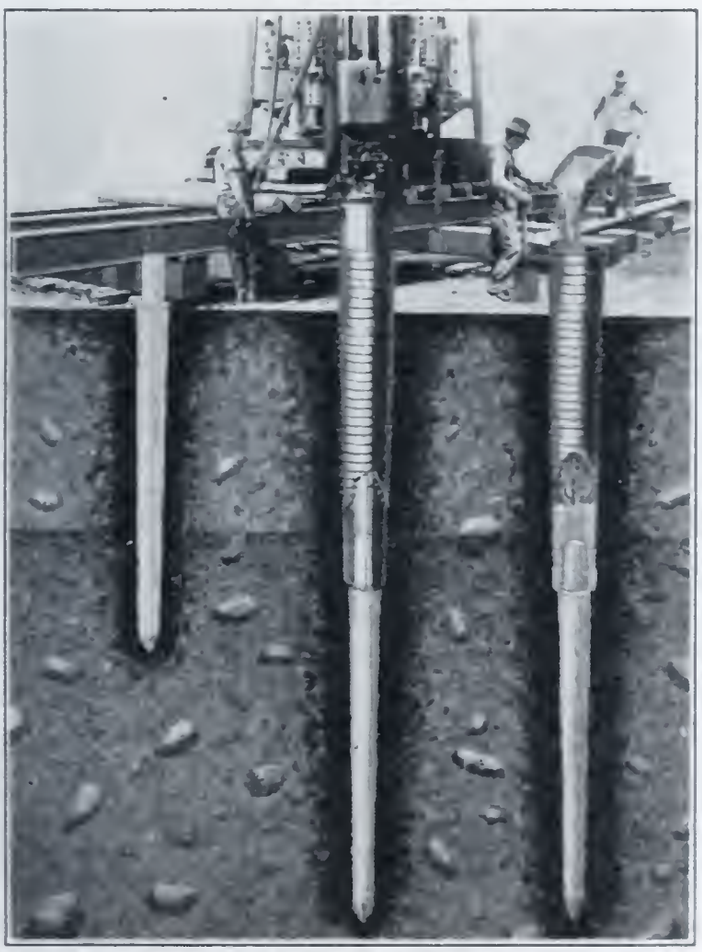

Fig. 15. Raymond Composite Piles.

quently necessary to carry the penetration a great depth to a substantial bearing. The concrete portion of the pile is brought down well below an elevation which is constantly wet. This avoids the excavation and heavy foundations incident to the normal construction of wood-pile foundations when the permanent water-level is materially below the grade of the footing.

The new River Rouge plant of the Ford Motor Company, involving new blast and open-hearth furnaces and power-station, is

located on ground of low-bearing value with no substantial stratum within 70 or 80 feet of the surface. The water level is 12 or 15 feet below the bottom of the footings. Some 15,000 of these composite piles were used in providing the foundations for these structures.

Fig. 16 illustrates in detail some of the shell and pile construction involved in this type of pile. The reinforcing rod is fastened

Fig. 16. Raymond Composite Piles. Features of Construction.

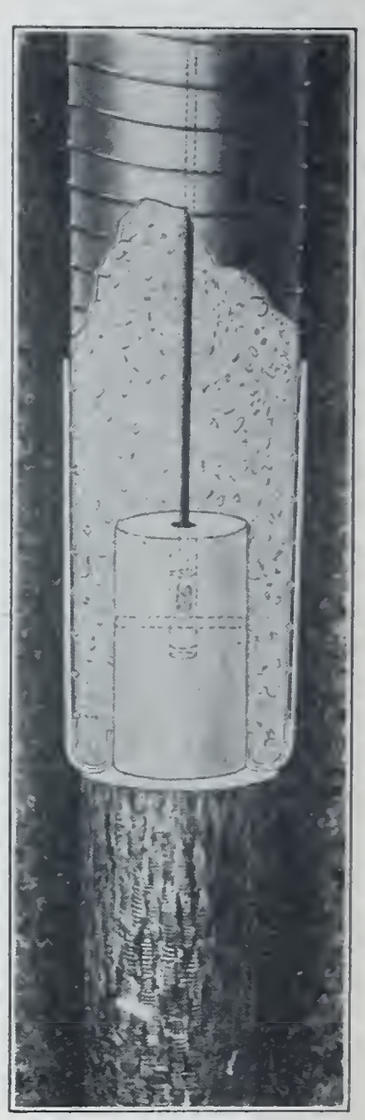

Fig. 17. Raymond Composite Piles. Construction of Joint.

securely to the pile by means of a dowel, thereby locking the two units together and forming a transverse strength equivalent to the strength of the dowel portion of the wood pile. Fig. 17 shows the detail of the joint. Special machines automatically cut the heads on the wood piles, the process taking less than a quarter of a minute.

The selection of the proper piling or foundation construction to meet any given conditions involves the consideration of many factors.

Wood piles are the least expensive per linear foot, but, of course, must be cut off at permanent water-level, and are limited in loading to the size provided by the natural growth of the timber. Frequently the carrying down of the footing to permanent water grade involves expensive sheeting, shoring, excavation, pumping and an excess amount of concrete. It is largely because of these factors that the concrete pile has been recognized as an economical construction unit. Since it can be made of almost any cross-section, it is customary to design it of a size sufficient to carry from two to three times as much as can be safely carried on wood piles. The consequent reduction in the number of concrete piles over wood piles very much decreases the size of the footings. The savings enumerated above are usually sufficient to overcome the cost of the concrete piles, which are from two to three times as much per linear foot as the cost of the wood piles. Frequently the total concrete pile foundation construction is from 25 to 50 per cent. less than a like construction on wood piles.

Thirty tons is recognized as a working load for approved, standard size, cast-in-place piles when used under ordinary conditions. Piles of larger cross-section are naturally loaded more heavily. Many city ordinances provide that one or two piles in every foundation site must be tested to twice their working load.

We American engineers are much more conservative in the loading of concrete piles than are our European brothers. The London City Council allows a working load of 60 tons on piles of cross-section 16 by 16 inches when driven through Thames River mud to substantial underlying material. In 1914 the writer observed the driving of 12- by 12-inch piles for the support of docks for the London port authorities for a loading of 50 tons.

One of the advantages in the use of the pile as a load-carrying unit is that the process of placing the pile automatically acts as a test of its carrying capacity. This statement refers to the resistance that the pile shows during the process of driving.

The "*Engineering News* formula" is recognized as a pretty accurate gage of the carrying power of the pile. It will be observed that the curve in Fig. 18 shows the formula used with a steam-hammer in which the steam is used only to raise the moving part. Modifications of this formula for different characters of hammer are well known to the engineering profession. In the placing and driving of piles it is

the general practice to continue the driving until encountering a resistance of at least four blows to an inch with No. 1 type "Vulcan" hammer, or eight blows to an inch with No. 2.

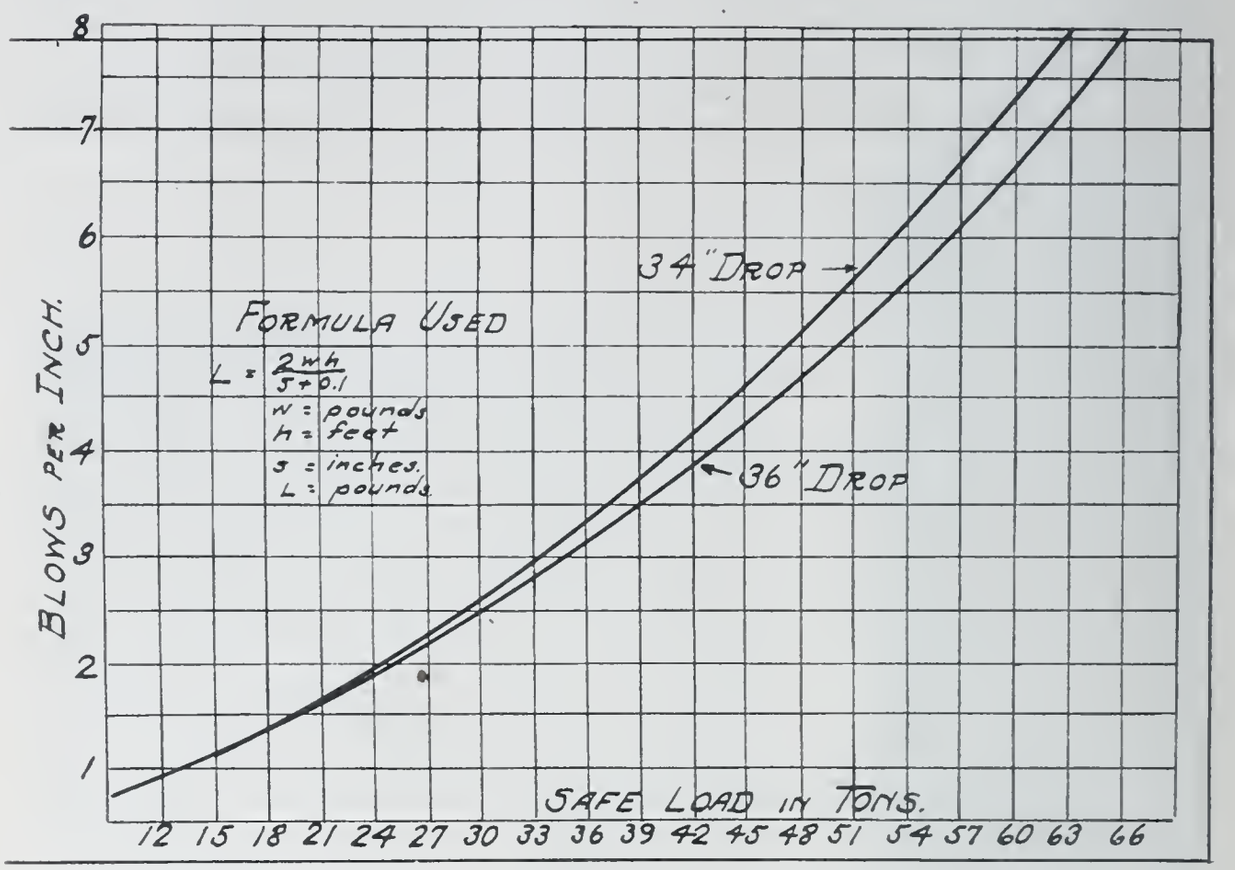

Fig. 18. Engineering News Formula.

It must be borne in mind that in driving a precast pile where a cushion is used, some modification of this formula must necessarily be taken into account. Furthermore, in the driving of cast-in-place piles, it is of great moment that the conditions in the ground which prevail at the time that the resistance is attained must be maintained in order to make sure that the actual carrying capacity is equivalent to the resistance indicated by the formula.

The load which can safely be put on a precast pile depends largely on the material through which and to which it penetrates. In the construction of piers and bulkheads in this country, where, in teredo-infested waters, reinforced concrete precast piling is becoming a recognized form of construction, the units, because of their unsupported length, are necessarily large in cross-section. They, therefore, provide a very large friction surface in addition to the footing area. In consequence, it is customary, in good ground (either sand or sub-

stantial clay), to give these piles a working load of from 40 to 80 tons. It is found that ordinary clay or good sand will give a very safe working friction load of 330 to 500 pounds per surface foot of area.

A notable case of heavy loading, where piles penetrate to the hard material overlying rock, exists in the deep water pier at Halifax, N. S., which is 235 feet wide and 800 feet long, a cross-section of which is shown in Fig. 19. These piles are 24 by 24 inches in cross-section and run up to 77 feet long. They are loaded to 100 tons each.

One of the large railroad companies in the United States, several years ago, made a series of experiments to determine the carrying capacity of cast-in-place and precast concrete and wood piles under the same soil conditions—namely, fairly soft quality of clay penetrating to a slightly harder stratum of clay. The results are illus-

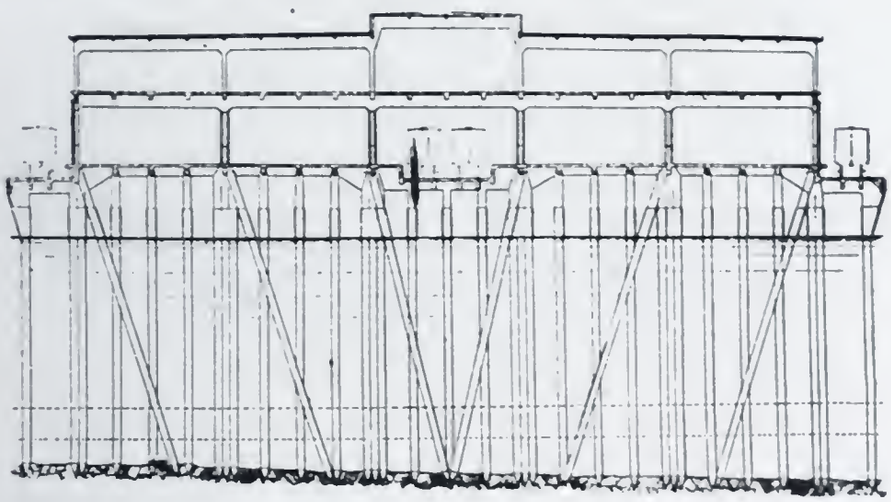

Fig. 19. Cross-Section of Pier, Halifax, N. S.

trated in Fig. 20. These experiments show clearly the advantage of driving on a steel mandrel, which can be abused to a much greater degree than either wood or precast piles. Furthermore, the efficacy of the taper of the Raymond pile is here shown in that its carrying power, both per linear foot and per square foot of surface area, is from 33 to 50 per cent. in excess of the other two types of piles.

A rather interesting analysis of the relationship of taper to friction per square foot is shown in Fig. 21. This information is based on an extended series of tests where the piles have penetrated a uniform material not extending down to gravel, hard-pan or rock. It is apparent from the information that the friction per square foot increases with increased taper, but the most marked increase is between 0.25 inch and 0.4 inch per foot of length. The determination

MICHIGAN CENTRAL RAILROAD
— PILE TESTS —

NAME	NO	DRIVEN	NAME	NO	DRIVEN
RAYMOND	1	14'-10"	CHENOWETH	7	22'-3"
RAYMOND	2	26'-6"	CHENOWETH	9	27'-6"
RAYMOND	3	28'-0"	CHENOWETH	10	32'-0"
McARTHUR	14	23'-9"	SIMPLEX	22	29'-0"
McARTHUR	17	13'-6"	SIMPLEX	24	18'-9"
WOOD PILE	—	24'-6"			

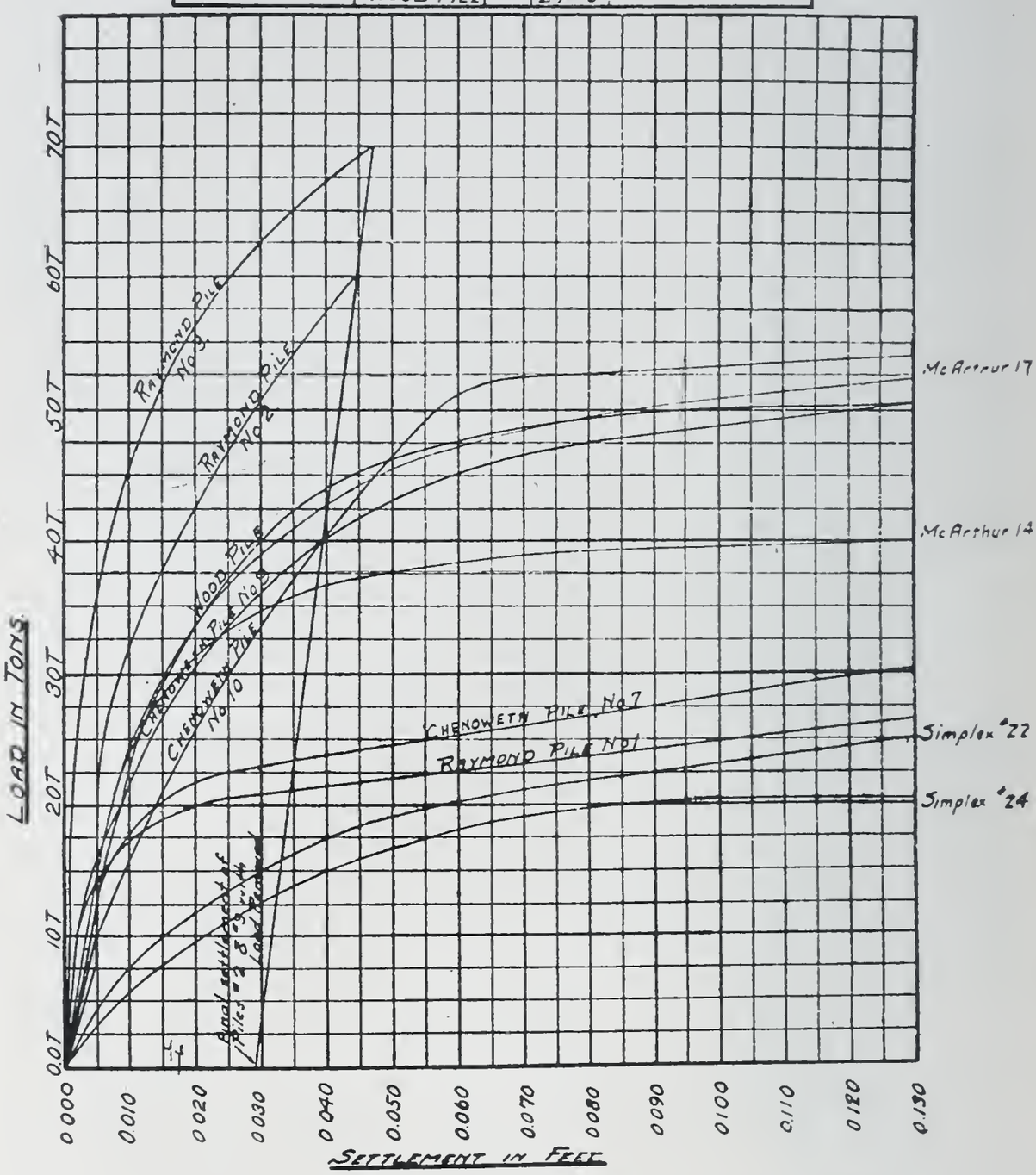

Fig. 20. Carrying Capacity of Piles.

of the taper is one of the important problems in the designing of a pile to meet average conditions. For that reason, the Raymond Concrete Pile Company has cores of different size and taper. It is found,

however that the 0.4-inch taper to the foot meets almost every requirement for a friction pile.

A rather interesting development of precast pile construction is shown in cross-section in Fig. 22. It will be observed that this member forms an interlocking reinforced concrete sheet pile, with spaces provided for the grouting of the steel members which form the interlock. This makes a permanent tight wall which is very much to be desired in confining soils of a certain character. This construction has been used in beach protection work and in retaining walls which confine sand. The Raymond Concrete Pile Company recently placed

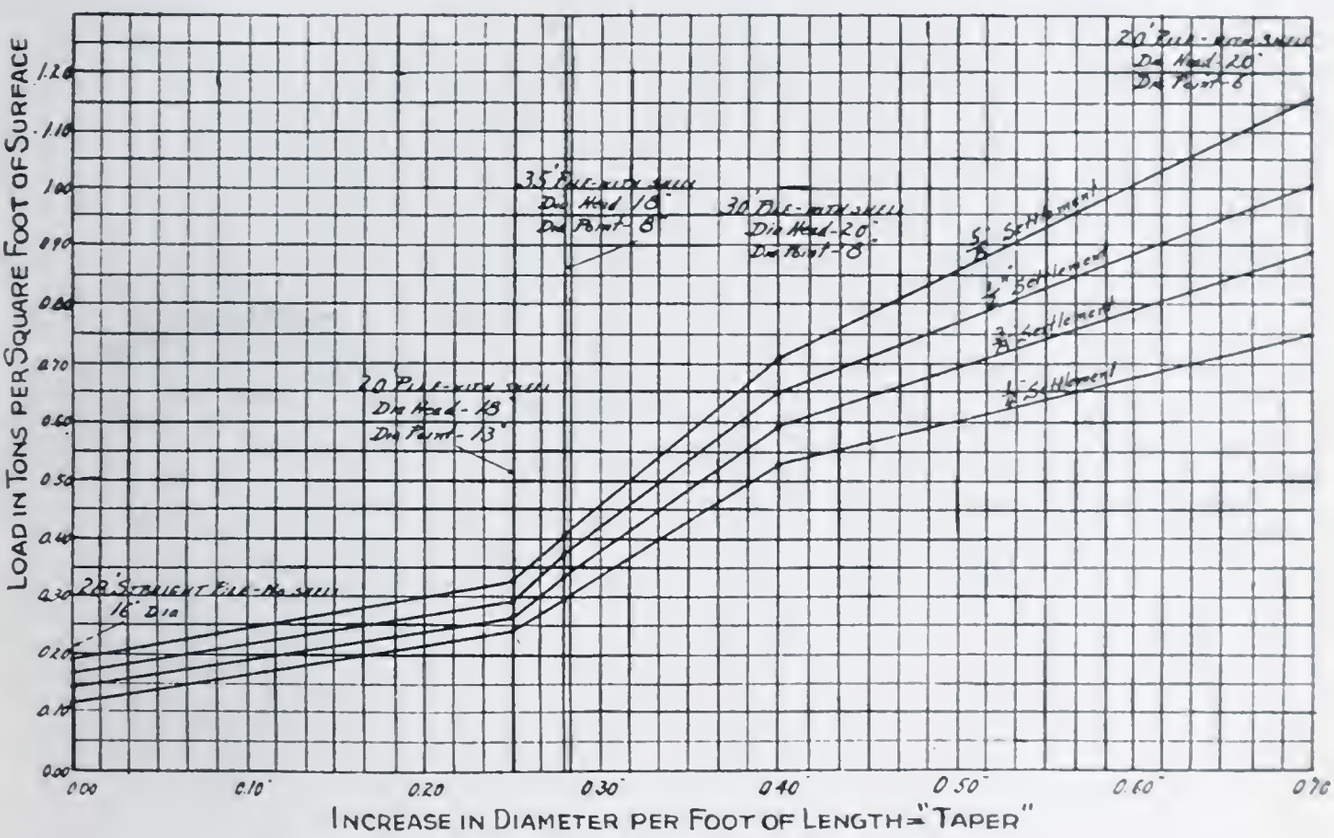

Fig. 21. Relation Between Taper and Friction.

several hundred of these piles as a wall around a large power-station in the Mississippi River at St. Louis. The construction is covered by United States patents held by the writer.

In the time allotted it is impossible to do more than touch upon the essentials of the concrete pile development in the United States. Several types of piles which are used occasionally have not been mentioned. Furthermore, there are many modifications of the general principles outlined herein which have a bearing on the pile industry. It is not the intention of the writer to slight in any degree the contributions which the development of these types has brought to the

pile industry, but it is impossible to cover adequately the whole field in the time and space available.

It has been the aim of the writer to avoid entering into the merits and the weaknesses of the different types of pile. That is an

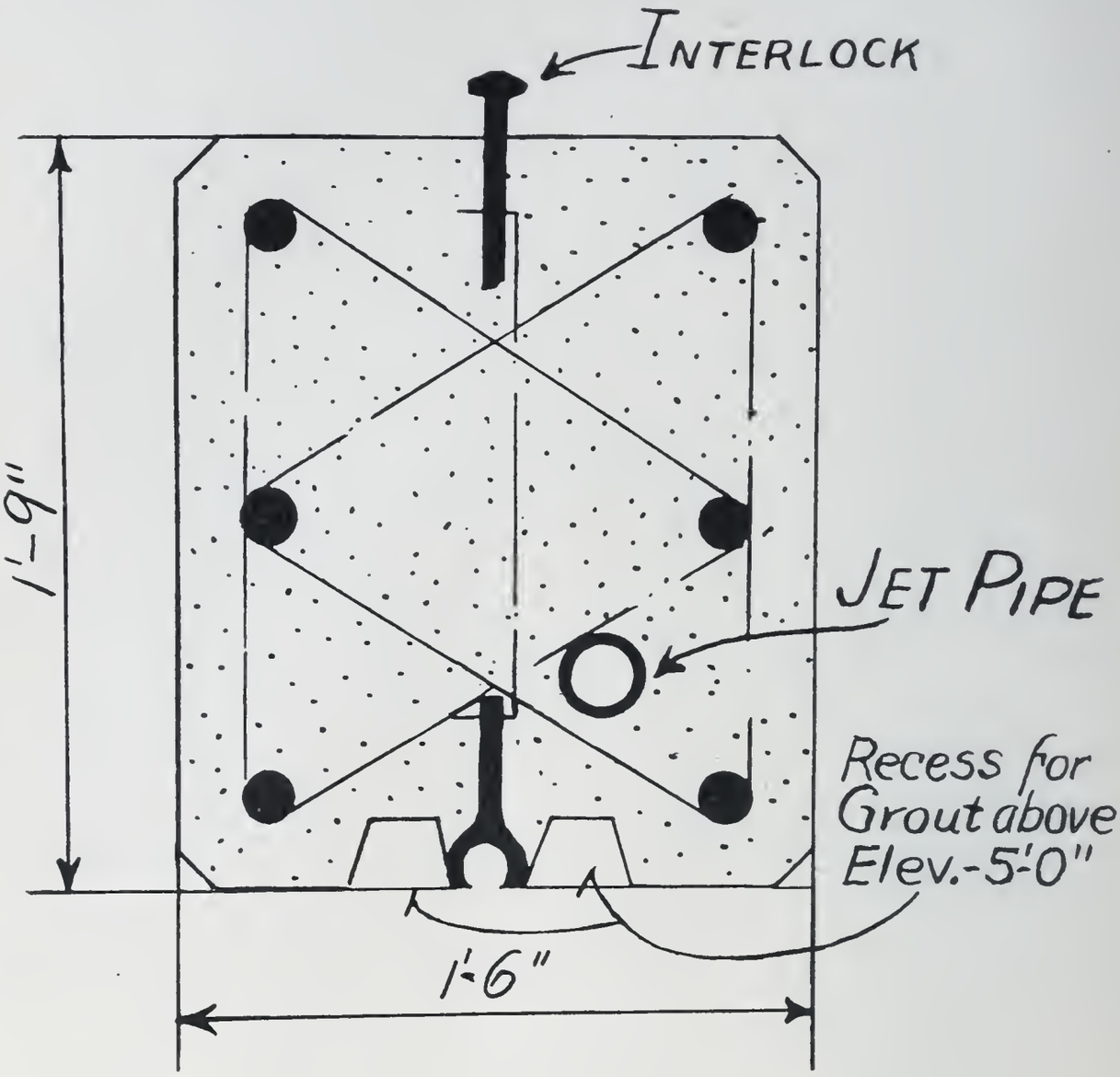

Fig. 22. Section of Sheet Pile.

engineering determination which hinges largely on the conditions prevailing at the site in question. The disease must, of necessity, dictate the medicine; however, it is of value to have some definite data regarding the remedies available. It is hoped that the foregoing may be helpful in supplying this information.

DISCUSSION

Mr. Julian Kennedy:* I do not know that I have anything to add, but I have been very much interested. I would like to ask a question as to the location of the teredo, where you have to look out for that most and what you have to do with your piles.

Mr. Maxwell M. Upson: The teredo is most destructive in the warmer waters. On the Atlantic coast, untreated timber is attacked as far north as the influence of the Gulf Stream is felt. On the Pacific, on account of the proximity of the Japan current, the entire coast is subject to its devastation. The substructures of the piers at New York proper have not been affected to any material extent for the reason that the sewage has apparently given the teredo and Limnoria indigestion or some other equally effective malady which causes them to seek other abodes. The teredo has manifested itself in the harbor both in and around Staten Island and in Jamaica Bay. Material damage has been done on the Staten Island structures.

It is interesting to observe a phenomenon that is described very thoroughly in a paper delivered last June before the American Society of Civil Engineers,† namely, that a slight variation in sewage or saline condition of the water may expose structures which have heretofore been considered immune. This is demonstrated in San Francisco harbor and bay. Piers that have been standing for ten or fifteen years were suddenly attacked and completely destroyed. Furthermore, the teredo and Limnoria seem to be able to overcome their aversion to the oils of creosote. Fifteen years ago engineers at Charleston felt assured that a creosoted pile would last from twenty to thirty years. To-day they give them a life of from seven to ten years. A committee of engineers appointed by the Harbor Board of New York made a report some three or four years ago with respect to this danger, and, since that time, it has been the policy of the Board to use concrete substructures where possible on all permanent improvements. The cost of concrete piling is, of course, somewhat greater than that of untreated wood piles, but not to a degree that makes its adoption impracticable.

*Engineer, Pittsburgh.

†Trans. A. S. C. E., v. 36, p. 416.

Mr. Julian Kennedy: How about the stone borers on the Pacific coast?

Mr. Maxwell M. Upson: For years, a shell-fish, somewhat like a clam (named Pholadidæ by scientists), has been known by engineers as a rock borer. All investigations thus far indicate that its activities are limited to calcareous rock and that it cannot penetrate into material containing an igneous aggregate. So far as I have any knowledge, the only operations of these animals on concrete occurred on the Pacific coast, where the borers penetrated into the cement mortar that was put around wood piles to protect them from the action of the teredo and Limnoria. This coating was so thin that nothing but fine aggregate was used—that is, sand and cement. Since the pholad borer or shell-fish makes its progress through the rock by the secretion of an acid which softens or dissolves the lime before mechanical action takes place, an igneous or hard rock necessarily stops its operation.

Mr. James S. Martin:* I wish to express my appreciation of Mr. Upson's paper and of the comprehensive knowledge of the subject displayed in its preparation.

There are a few points which I wish to bring out. One of these points is the desirability of an actual test of the piles, wherever work of any importance is being done. Driving a pile down till it takes four blows of the hammer to drive it one inch does not prove that the pile will sustain the load placed upon it when the construction is completed. In the case of the Pittsburgh Terminal Warehouse, South Side, Pittsburgh, built about 1904, one type of the piles which were tested settled considerably beyond the permissible limits before the entire test load had been applied, even though these piles had been driven to refusal.

The Naval Air Craft storage building, at the League Island Navy Yard, erected during the war, was built on piles which had been driven to refusal, and yet the building settled about two feet, necessitating an expenditure by the United States government of about $250,000 to restore it.

*Structural Engineer, Philadelphia Co., Pitttsburgh.

The Westinghouse Electric & Manufacturing Company building, at Thirtieth and Walnut Streets, Philadelphia, put in this year, began to settle so badly that vigorous measures had to be resorted to in order to save it.

I could give other examples, but these are enough to show that the simple refusal of the pile to move more than one-quarter of an inch per blow does not prove that the pile will safely maintain the required load.

The piles should be tested, and tested in groups if possible. An editorial in the *Engineering News-Record* of January 22, 1920,* calls attention to the fact that a test on a single pile is not a positive proof of the bearing value of a group of piles. For instance, a pile 40 feet long may be able, by means of the friction of the earth on the surface of the pile, to distribute the load to an area of 25 square feet at the foot of the pile. This would be over a circle 5.642 feet in diameter. If there are four piles in a group, spaced three feet on centers, the portion of the surface of the piles toward the center of the group would distribute the load over territory common to all the piles. Taking a radius of $5.642 \div 2 = 2.821$ feet from each pile, and describing arcs around these piles till these arcs intersect each other, we will have an area of 66.12 square feet enclosed for the group, which equals only 16.53 square feet for each pile, instead of 25 square feet. If there are nine piles arranged in a square, three feet on centers, we would have an area of 125.246 square feet for the group, which would amount to only 13.92 square feet per pile. There have been cases of trouble where a single pile has been tested, and the value of the single pile multiplied by the number of piles in the group to determine the bearing value of the group. For this reason I believe that, wherever possible, the tests should be made on groups of piles rather than on single piles; or, if that is not possible, proper allowances should be made in determining the safe loads for the groups of piles.

I would also say that I do not consider it safe to depend too much on the compression of the soil, due to the driving of the pile, on the assumption that this compression increases the bearing power of the pile. This compression is generally very much localized around the pile. This is shown by the fact that, when concrete piles are being driven in groups, the driving is being done for piles adjacent to those

*V. 84, pp. 161-162.

in which the concrete has been freshly placed, often within three feet of the soft concrete, and yet when these piles are dug out for an exposure test there is seldom any distortion. In fact, I have yet to learn of an authentic case of such distortion. Sometimes this compression extends such a short distance from the surface of the pile that the only advantage to be gained from it is that it virtually increases the diameter of the pile by a few inches. If we could say that this compression is permanent, it would not be so bad, but the fact that piles will often settle after being driven to refusal shows that in some kinds of soil this compression is gradually dissipated through the surrounding earth, leaving the pile in soil which is no more solid than it was before the driving was done.

I wish to emphasize the fact that a type of pile may be a success in one place and a failure in another. The success of any type of pile can be determined only by a test of that type in the location where it is to be used.

My personal preference has always been to have the piles driven down to a good bearing stratum wherever this is possible.

Mr. Maxwell M. Upson: The point is well taken. I think too much can not be said of the importance of making tests prior to the driving of piles. The resistance, or carrying capacity, of a single pile may give most misleading information. Recently the company with which I am associated experienced a very serious difficulty which well illustrates this point. The owner gave us borings of the soil which we supposed had been taken with great care. They showed good, non-compressible material all the way from the surface to rock. Piles were driven in this material to good resistance, but when the building was up eight stories signs of settlement were evident. Immediately new borings were taken, which revealed the fact that the original were entirely wrong and that from five to ten feet of peat and silt underlay the surface stratum of sand and gravel penetrated by the piles. The loading of the whole area caused the underlying soft material to be compressed—in some areas as much as eight inches. The rectifying of the difficulty involved carrying the pile down through the soft material to rock and substituting this type of foundation in place of the original. Such errors are bound to occur if accurate and sufficient information is not available.

The last speaker's suggestion is exceedingly pertinent. The facts must be known before determining upon the best type of foundation construction. It is, in my opinion, impracticable to attempt to load a large number of piles; first, it is almost impossible to get a load sufficient to secure a true result; and, second, the information, even then, is not worth the excessive expense. The cheapest and most accurate procedure is to secure definite data on the material underlying the site. This is essential and should be given attention above everything else in solving a foundation problem.

Mr. Norman F. Brown:* Mr. Upson, inasmuch as you use your own specifications for concrete, I would like to ask what character of mixture of aggregates you specify for standard, or do you vary it for different kinds of soil, and what materials, if any, have you determined to be useful for either densifying the concrete or for increasing its impermeability?

Mr. Maxwell M. Upson: Perhaps Mr. Ferguson, who sits near you, can answer that question better than I. He and I happen to be on the same committee of the American Concrete Institute which deals with destructive agents and protective treatments. In this committee we have given much attention to the making of dense and impermeable concrete. So far as I have been able to determine, the Abrams sieve test, analyzing and proportioning the aggregates, is perhaps the most scientific and practical method known. I think that by following it carefully, dense and fairly impermeable concrete will be obtained. Some of my friends practice a simpler method which I feel gives fairly satisfactory results. This consists of mixing aggregates in varying proportions, starting perhaps with a 1:2:5 and increasing up to a 1:1.5:3. These various mixtures are put in a unit measure, carefully struck, and weighed. Care is taken to see that the moisture of the material is constant. The mixture which shows the maximum weight gives the maximum density and impermeability. It is interesting to watch these determinations as they progress, since the curves of density and weight seem to run fairly parallel. This "rule of thumb" method may be of material help in approximating a perfect mixture.

*Brown & Reppert, Inc., Pittsburgh.

All of us who have had to do with concrete know how many varieties can be produced from the same material. A combination of materials and the careful watching of the water are essential in the production of a concrete that is going to withstand the seepage of water. This is one problem which must have careful attention on the part of engineers and constructors. We all believe in concrete, and are sure it is a safe construction material because we have so many evidences of its permanency, but there are also, unfortunately, some evidences of failure. These failures are largely due to gross carelessness in treating of the fundamentals underlying the mixing, placing, and curing of concrete. The desideratum is a concrete that will show a maximum resistance to the passage of water through it. The continued percolation of water through concrete is sure to bring destruction sooner or later. As time goes on and the difficulties develop which have taken years to bring about, we are more and more impressed with the necessity of a scientific knowledge on the part of all who have to do with the design and construction of this magic material. We continually see concrete that has stood for years; and, perhaps next door, we find a material that can be picked into pieces with the fingers. The difference between these materials has not come about through chance. One embodies good workmanship and materials, while the other does not. All of us should familiarize ourselves with the investigations of Dr. Abrams, which are thorough and scientific.

Mr. J. A. Ferguson:* I have been deeply interested in Mr. Upson's paper and in the discussion. I heartily agree with Mr. Upson's remarks in regard to the destructive effects of water percolating through concrete. I have seen and have had to correct several structures that had been severely damaged by percolating water. There are several methods that can be used to prevent percolation, careful attention to make the concrete as dense as possible being the most easily used. I believe that, in the very near future, there will be some very effective chemical additions made available for ordinary use that will not only prevent the percolation of water, but will also bring about insoluble compounds in the cement, as well as strengthening the concrete in which they are used.

*Secretary-Engineer, Building Code Committee, City of Pittsburgh, Pittsburgh.

I would like to ask Mr. Upson what measures are generally used to take care of buoyancy in piles when adjacent piles are driven quite close together. Is it usually considered dangerous when this buoyancy occurs, forcing upward the piles previously driven and disturbing their equilibrium in the ground?

Mr. Maxwell M. Upson: Mr. Ferguson is quite correct in his assumption that piles in certain soils heave. It is due to an unusual soil condition. "Elasticity," perhaps, best describes the characteristic of the material where this phenomenon is most prevalent. The soil displaced in driving a pile heaves, and, in heaving, carries with it piles previously driven. I have seen this upward pressure so great that the heaving pile broke in two a 12- by 12-inch timber encountered in its upward movement. This tendency does not seem to be of great moment when all the piles are loaded. The confining of all the soil permits each pile to take its designed load. It is important, however, to exercise care to see that the piles are not broken by this movement. This is probably best remedied by the use of reinforcement to avoid such breakage. Normally, the shell on a Raymond pile is strong enough to avoid this possibility, but sometimes it is wise even to supplement the shell with reinforcing steel.

Mr. J. A. Ferguson: In line with Mr. Upson's statement that the kind of ground encountered determines the kind of pile that will serve best, I should think that the use of piles cast in place in large footings where the number of piles cast is considerable, and where the ground is yielding, would be attended with considerable danger unless there is a shell in place to hold the ground positively to position and shape. Where the ground is yielding, the piles driven subsequent to the first ones could so disturb the surrounding ground that it would be forced into and through those first filled with concrete. This would tend to break the first piles into sausage links with nothing but ground between, thus resulting in only a short pile where a long one is wanted.

Mr. B. A. Ludgate, *Chairman*:* In the event of some of the piles heaving up, due to driving too closely, what attempt is made to drive them back into place, and with what success?

*Assistant Engineer, Pittsburgh & Lake Erie Railroad, Pittsburgh.

Mr. Maxwell M. Upson: We have done this, but usually the driving of one pile back into position results in lifting others up. It is a never-ending undertaking.

Mr. S. C. Carter:* Will that pile settle?

Mr. Maxwell M. Upson: So far as I know, there has never been any settlement of structures placed on piles driven into elastic soil of the character described. As previously explained, the loading of all the piles and the confining of the earth around the tops of the piles so confines the soil that full friction on the part of the pile is developed. I was apprehensive with respect to this unusual phenomenon when I first encountered it about fifteen years ago. On investigation, I found engineers who had had wide experience in this character of soil, and, on their advice, adopted the policy already outlined. The answer to this, however, is like the answer to all foundation problems—the local conditions and exact soil conditions must be thoroughly considered before determining upon a policy.

Mr. W. M. Austin:† I would like to ask Mr. Upson a question about the precast pile, with a steel-casting point, which is driven by means of a channel iron bearing against a flange on the head or point. Has it ever happened that, in applying the blows of the pile driver to the bottom end of the pile, the sudden acceleration in soft soil produced a tension in the concrete near the bottom sufficient to rupture it, leaving only the reinforcing rods to hold the two ends of the pile together?

Mr. Maxwell M. Upson: So far as I know, only two or three contracts have been executed by the Giant Company. I have no knowledge of the withdrawal of any piles ever driven by them, but your inquiry is a natural one. I assume the pressure of the earth affords a fairly effective friction between the channel and the pipe so that some of the blow is transferred to the concrete before it gets through to the point.

*Construction Engineeer, Koppers Co., Pittsburgh.

†Electrical Engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Mr. Harry J. Lewis:* I would like to express my appreciation of the fairness of the presentation of all the different types of piles by the author. I have used concrete piles a little, and I have been guilty of using precast piles and Raymond piles within 75 feet of each other on two different structures, because I thought the one was proper in one place and the other was all right for the other place. One was a case of lateral pressure, where I thought I needed a precast pile that could be reinforced; and the other was farther back, where a vertical load was to be carried straight down to a layer of original soil that proved to be good. In every case of using a Raymond pile, I have always shoved in a little steel reinforcement.

Mr. Edward Godfrey:† Mr. Upson has given us a paper that is valuable and interesting, on a subject that is of vital moment to all who have to deal with structures.

The behavior of piles during their installation, and the service that can be expected of them after they are in place in a foundation, are both matters of importance to designers and builders. Some matters of importance that could well be included in this paper or its discussion are the weight of hammer most suitable for driving precast piles. I believe that precast concrete piles should be driven with a very heavy hammer, because a heavy hammer is less liable to shatter the head of the pile than a lighter one. The weight of the heavy hammer is communicated as a pressure through the length of the pile; whereas a light hammer, even with steam behind it, expends a great part of its energy near the head of the pile. A light hand hammer, striking on the end of a steel bar, will peen a head on the bar, whereas a heavy hammer will tend to drive the other end of the bar into the thing it may be in contact with, or to bend the bar. In a similar manner, the light hammer on the concrete pile tends to distort and shatter the head, while the heavy one exerts a better driving effect.

In the matter of reinforcement, hooping or spirals, with some longitudinal steel, has proved to be the best type of reinforcement for precast concrete piles. This affords another proof of the error of reinforcing columns with square-shaped ties spaced at intervals, if such proof were needed.

*Consulting Engineer, Pittsburgh.
†Structural Engineer, Robert W. Hunt & Co., Pittsburgh.

Mr. Upson mentions the advantages of a taper in piles. I agree with him that there are several advantages in tapered piles. In the first place, the frictional resistance is increased as the pile is driven further and further into the soil, because the driving compacts the soil around the pile for its full length, and this increases the side pressure, and thus increases the side pressure of the soil against the pile.

Another advantage in the taper is that, as the column action is resisted by friction on the side, the effective length of the column is greatly reduced, and only a portion of the load is applied on the lower end of the pile. The chief advantage, however, is in the compacting of the soil. In driving cylindrical piles, the soil is largely driven ahead of the pile and not much compacting of soil is effected in the upper strata. There is much benefit to be derived from compacting the soil immediately surrounding the nest of piles. Even this compacting alone, if the holes were simply backfilled with compacted earth, will enable the soil to carry a very much greater load, as it is well known that pressures at or near the surface are rapidly distributed laterally if there is any compactness in the soil.

Mr. Upson mentions the pretest system of underpinning. By this system short lengths of cylinders, superimposed upon one another, are jacked down into the soil, using as a reaction for the jacks the superstructure to be underpinned. As a method of underpinning this has decided advantages. Underpinning, by its very nature, is a makeshift. It is undertaken where a foundation is inadequate, or has been rendered inadequate by reason of added weight or decreased supporting power of an existing foundation because of excavation close to the foundation. But this pretest method has also been employed in original foundations, and, in my judgment, this is unwarranted and fraught with danger.

In the *Scientific American,* December, 1921,* there is an article describing the making of the foundation of the Hide and Leather building in New York, an 18-story reinforced concrete building. In this work the building was started without a foundation and, as it was built up, the pretest pile system was employed to push small disjointed cylinders under the structure until the jacks met a resistance of 75 tons on each pile. Then steel posts were introduced, surrounded

*V. 125, pp. 132-133.

with concrete, and these were to receive a calculated load of 50 tons each.

I fail to see the propriety of thus using underpinning methods in an original foundation. If I found a truss or column in steelwork that was inadequate, I would reinforce it in place, if this were practicable; but I would not set up a truss, in original construction, inadequate in size, and then patch it up in place, even if this were the most economical method. Original construction should have every benefit of uniformity of action of several parts and elements.

It can scarcely be argued that a succession of short cylindrical blocks pushed down into the ground is equivalent to an integral pile, molded in place, or precast, tapered and driven into place; though there may be circumstances where the pile cannot be driven, and the short blocks solve the problem. If these blocks are not tapered or pointed at the end, but square ended, as they seem to be, skin friction can scarcely play any major part in their supporting power; and it cannot be questioned that skin friction is of immense value in the supporting power of piles. Some tests in Chicago, recently published, prove the great value of skin friction, as shown in *Engineering News-Record,* May 18, 1922.* Skin friction of a four-foot cylinder, 70 feet in the ground, was computed to be supporting 315 tons, the bottom of the caisson being undercut. Furthermore, skin friction is more reliable in some respects than end reaction. End reaction may, by accumulation of the force of a nest of piles, finally break through a stratum that has supported the individually tested piles. There would scarcely be a great skin friction developed in a square-ended pile of uniform diameter, and there would not be much compacting of the soil in the upper strata. The succession of short blocks may be penetrating the ground in a vertical position, and it may not be so penetrating. Unequal resistance, as that offered by a boulder or other obstruction, may cause a block to tilt. Also such eccentric pressure may crush the cylinder, and the succession of short blocks may be simply grinding up blocks already driven in, instead of penetrating to a good bearing.

I do not think that a test of 50 per cent. in excess of the load to be carried is conclusive as insuring freedom from settlement. Furthermore, the jacking down of a pile beside ones already in place will

*V. 88, p. 824.

relieve load from those already in place and disturb their bearing power or the distribution of the load.

Mr. Frank G. Cunningham:* We appreciate the opportunity of reading Mr. Upson's paper and we exceedingly regret that a previous engagement makes it impossible to be present and to listen to the delivery of the paper by Mr. Upson. We congratulate Mr. Upson on the thorough knowledge of the industry displayed by this paper. We would like, however, to elaborate somewhat on the reference made to the Simplex system.

Mr. Upson's reference to a reason for the development of the Simplex pile is different from our understanding, in that the best information we have is that the Simplex system was developed in an effort to overcome a difficult foundation problem at the Washington, D. C., barracks in 1902 or 1903. The work was done by the Cranford Paving Company, of Washington, D. C., and under the direction of John Stephen Sewell, Captain, United States Engineers. The results obtained were so satisfactory that the Cranford Paving Company was very much interested in the further development of the system, and it was at this stage of the development that knowledge was obtained of the existence of the Raymond patents. It was therefore due to the realization of the possibilities of this method of constructing concrete piles that the method now known as the Simplex system was adhered to and developed.

Mr. Upson's description of the Simplex system is accurate and needs no comment except that we believe it well to draw attention to the fact that the method which he describes as the "alligator" point, to our best knowledge, was abandoned some years ago by all of the contractors engaged in placing Simplex piling. The importance of point bearing became so apparent that it was considered advisable to provide this feature at the cost of the point used.

There is another type of Simplex pile, known as the molded-inserted pile, to which Mr. Upson makes no reference, and which we believe is of interest. In this method, premolded, reinforced piles are manufactured as usual in such construction. These sections are octagonal piles, 13 inches in diameter. The usual Simplex mandrel is driven into the ground, and closed at the end with a cast-iron point.

*Treasurer, Simplex Pile Foundation Co., Pittsburgh.

A small quantity of plastic concrete is filled into the mandrel, to form a base for the molded pile, which is then lowered into the form and onto this plastic concrete. Sufficient soft grout is then poured into the mandrel, and as the mandrel is withdrawn the grout flows down, surrounds the molded section, and fills the space occupied by the mandrel. With this method the molded pile is placed with none of the usual objections to this type of construction, in that the molded section is not subjected to the unusual stresses set up when it is driven into place. The advantages of this type for extremely heavy loads and for very unreliable soils are self-evident.

A point wherein we disagree with Mr. Upson's conclusions is the value of tapering a pile.

In the *Engineering News-Record* of January 22, 1920,* there appeared an article on the failure of a grain elevator foundation at Portland, Ore. In connection with this article there appeared an editorial (referred to by Mr. James S. Martin, above), the concluding sentence of which summed up in the following language the knowledge to be derived from the failure:

> "The settlement will, however, serve to call new attention to the fact that piling is largely a device to transmit loads from soft soil to one of greater carrying capacity and that, unless it reaches such a stronger stratum, it tends to be a rather uneconomical form of spread footing."

The Simplex pile is based on this theory, and the apparatus used is such that piles can be made of any reasonable length required by the conditions.

It is the writer's feeling, from a number of years' observation of pile-driving operations, that in many cases piles have been used where a much more economical and fully as reliable foundation would have been obtained by other forms of foundations—principally mat foundations.

Tapering of the apparatus used to place concrete piles necessarily limits its length, and therefore limits the length to which the pile can be driven. The apparatus used in placing Simplex piles, being of constant diameter, can be provided in any length and can be added to by means of extension pieces where necessary.

Another point to which special attention might be called is that the Simplex pile, being molded in intimate contact with the soil in

*V. 84, pp. 179-182.

which it is placed, has the advantage of cementation to this soil with the resultant high frictional value.

It has been developed that the Simplex pile takes full advantage of the supporting value of the soil through which it is driven, in addition to its point bearing.

Mr. Maxwell M. Upson: I can think of no case where piles have traveled longitudinally except where they have been driven perhaps near a bank or near a waterfront, in which case the driving of the outer piles first may often result in their displacement if the inner piles are driven subsequently. I do know of cases in foundation work where the ground has been wedged out so that the stakes which were set to locate the piles have traveled out of place. It is a natural tendency of mobile soil to travel when pressure is applied behind it. I have no doubt that a small motion often occurs as a result of this tendency. It has, however, never been of sufficient moment to cause discussion.

Mr. B. A. Ludgate, *Chairman*: In the event of the structure being placed on piles driven vertically into fairly soft earth, is there any record of the whole structure moving over sideways, due to insufficient resistance on the sides of the piles?

Mr. Maxwell M. Upson: I have not heard of such an instance except in wharf construction where the piles had a point bearing and where there was no material to give lateral support to the top of the piles. There have been one or two instances where serious failures have occurred because no provision was made for taking care of the bracing or lateral support.

THE ENGINEER'S RESPONSIBILITY*

By Morris Knowles†

It has been customary for many years for the retiring president to deliver an address. This has been frequently upon a subject drawn from the field in which the incumbent of the office has been particularly engaged, or some special kind of work in which he has conducted research. In casting about for such a subject it occurred to me that there was nothing of greater commanding interest to the engineer of to-day than that chosen as the title of this paper. It happens to be one, also, in which the speaker has had some special interest and upon which he has expressed himself from time to time.

INTRODUCTION

Timeliness of Topic. Article 2 of the charter of the Engineers' Society of Western Pennsylvania reads:

"The object of this corporation shall be the advancement of engineering in its several branches, the professional improvement of its members, and the encouragement of social intercourse among men of practical science."[1]‡

We seem to be carrying this out in our arrangement for club-rooms and in the proposed extension of these activities. Our by-laws also indicate an interest in matters of public affairs, for Article 6, Section 10, reads as follows:

"The *Civic Affairs Committee* shall be charged with the duty of investigating and reporting upon the relationship of the Engineers' Society of Western Pennsylvania to matters of public interest."[2]

For a number of years presidents of the national engineering societies have spoken upon subjects akin to that which we will discuss to-night. The recent addresses of the retiring presidents of the American Society of Mechanical Engineers and the American Institute of Consulting Engineers; the address recently made in this city by the newly elected president of the American Society of Civil Engineers; the address by the Secretary of Commerce before the Engineering Council in Washington only two weeks ago, and that of the

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†President, Morris Knowles, Inc., Pittsburgh.
‡See Bibliography at end of paper.

president of Columbia University at the same time, all directed toward this same topic, indicate very strongly its important bearing upon the activities of the engineer of to-day.

The service of a Cabinet officer, who is a recognized engineer, once suggested as a candidate for President; the discussion and comment brought about by the removal of the director of the United States Reclamation Service; the attitude as to the licensing of engineers, both intrastate and interstate, and the great divergence of opinion on this subject and inability, up to the present time, of members of the profession to get together and work for a common purpose; the recent bridge controversy in this county, suggesting the lack of co-ordination of engineers to act for the common purpose, all indicate various phases of this important problem. We are glad to say in passing, however, that there seems to be a better working understanding now with regard to the design and construction of such structures, which are so largely of an engineering character, and a better realization that all structures suited for their purpose make for beauty, and that engineers do understand attractiveness of design and harmony in location, which is the real essence of art.

Even in the membership of our Society there are two who are burgesses of boroughs, several acting as borough managers, or as engineers in a field which is practically managerial. Recently one of the prominent members of this Society has been elected to the office of county treasurer. The appointment of an experienced and capable engineering administrator as county Director of Public Works—a position practically that of county manager—is another indication of the timeliness of the topic. I wonder if it is realized that the president of the Chamber of Commerce of Pittsburgh and five of the directors are engineers and members of this Society. Certainly there is more and more a growing appreciation of the engineer as other than a mere technician—he is a man and no mean citizen.

Definition of Engineer. It is well that we should understand the manner of man about whom we are talking, and this leads us to a discussion of the definition of an engineer. Civil engineering is not merely surveying, and the speaker's own calling, that of sanitary engineering, is not a mere euphemism for plumbing. Nor is the engineer, as portrayed by Hopkinson Smith (himself no mean engineer), a wizard for whom ingenious machines do the work of almost human

intelligence. Some look upon the engineer as gifted with some sort of supernatural power—one for whom networks of rails and wires are spun over the land; great prisms of earth are scooped out to form canals; giant structures of stone and steel and concrete rise, and all the materials and forces of nature bow down in the presence of the derrick and steam whistle, symbols of his authority.

One of these ideas is as far from the truth as the other. The engineer is neither artisan nor wizard, but rather he is a student of natural science, the trained thinker and the experienced applied scientist. Tredgold's definition seems to fit best this type of man, as "One who directs the great sources of power in nature to the use and convenience of man." But to be really deserving of the name, the engineer will enjoy not only this work, but doing it economically and efficiently. This truth has led to another definition, somewhat less classical, which describes the engineer as "A man who can do for one dollar what any fool could do for two."

W. E. Wickenden, assistant vice-president of the American Telephone and Telegraph Company, now engaged by council of the four founder engineering societies on engineering education, to study the subject of engineering education, defines an engineer as "A person who is highly skilled in the control of materials and energy of nature and in their adaptation to *social and economic ends*." [3]

President Nicholas Murray Butler, of Columbia University, says: "I suppose an engineer, broadly speaking, is one whose task is to apply means to definite ends in the material life of man under the limitations of economic law." [4]

Engineers have existed in all ages and at all times (witness the great works of antiquity), but their work has only recently been recognized as a science, and not simply as an art. It is one of the youngest of the recognized professions and perhaps engineering education is not over one hundred years old.

In interpreting any of the above definitions and considering them together as fairly characteristic of the engineer, one must not fail to understand that *human nature* is not the least important of the "sources of power in nature." The execution of large engineering works requires large-scale operations; employment of great numbers of people; determination of incomes and living conditions; dealing with boards of directors, city councils, legislators and voters, and

securing money from thousands of pockets. More and more, engineering becomes a "direction of the forces of human nature," and he who does not appreciate this has but an incomplete idea of the real significance of the engineer and engineering work.

ENGINEERING A PUBLIC SERVICE

Group Work. Why is engineering a public service and wherein lies the important distinction between engineering and other professions? The lawyer usually conducts his case independently and deals with individuals; the doctor gives a personal service and fights single-handed the battle for life or health of the individual patient. On the other hand, the engineer can do little, if anything, by himself and seldom does work for the benefit of an individual. At the very beginning of his career as a rodman or chainman, he works with a number of others. He may be a lesser light in the execution of work or, later, a manager; but always he works again with numbers of people and, generally speaking, he cannot do anything alone. In all of his relations he works in groups, by groups and for groups.

Public Influence of Engineering Work. All of his work has a profound influence upon the health, safety and welfare of large numbers of people. The execution of those things which are commonly required as community functions, such as highways, railroads, stream regulation, canals, water-supplies, drainage, waste disposal and city building, are problems which determine the destinies of millions of people.

In a recently issued bulletin of the Federated American Engineering Societies, Mr. Koch, of Dallas, Tex., member of the Executive Board, says:

> "The people who use and profit by the works of the engineer, such as the electric lights, bridges, railways, street pavements, etc., do not come into direct personal contact with the engineer who was responsible for the construction; but they see only the finished product, whereas the physician and the lawyer have actual personal contact with their clients. The continuation of this 'working behind the scenes' and the lack of participation by the engineer in the social and political interests of the community will, no doubt, tend to keep the social progress of the engineering profession in an atrophied condition. Such unbalanced growth will, of course, be reflected in time in the technical advancement as well." [5]

This is why we are interested. If there be atrophy in one line there is likely to be stagnation in other lines. There are other reasons, also, why we are interested in this public nature of engineering service. In most communities as much money is raised for public works and related activities as for all other municipal functions, such as safety, health and education. The great amounts of county and state appropriations are for highways, parks, rivers and water terminals. Our great national debt for war construction, river and harbor improvement, and highway and other contributions to states, all indicate vast sums of public money which are being spent for work in which the engineer is vitally interested and for which he is intimately responsible. The public character of these works has an intimate and direct influence upon everyone, and service upon them creates special opportunities for civic leadership, thus greatly increasing, rather than diminishing, the engineer's responsibility.

As Secretary Hoover stated in his recent Washington address above mentioned:

"We are facing a time in the development of our civilization when we must find some sort of a bridge between the extreme individualism of the last century and the possible inroads of those forces that would extinguish that individualism entirely. . . . If the engineer is going to take his part in this community, is going to give expression to those things that he can express best, he must start with a sense of his public obligations as well as his professional knowledge."[6]

Again, as President Butler so well stated at the same conference:

"These public interests won't wait forever. It is a mistake to suppose they belong to political parties. They belong to all of us. We or our ancestors made them. They are left to us as trustees. We are responsible for the work of the social, political and economic systems, and it is astonishing how much of this work would fall under the head of engineering, properly described and defined.

"So I say to you, gentlemen, that the field in which you are working, however broad or narrow your particular interests may be, is of the very largest public concern, not alone because your enterprises have a public reference and interest and are often maintained by public authorities, but because you are abutting on public problems that, on the surface, do not appear to be related to engineering at all, but are related to that good citizenship, and that effective citizenship, which every well-trained and high-minded American engineer will use to illustrate in his own person."[4]

In his inaugural address, President Sir Charles Langbridge Morgan said before the Institution of Civil Engineers recently:

"The task of the twentieth century is to bring back to life some of that order and leisure and spaciousness which was submerged in the too hasty tide of Victorian prosperity. Engineers who . . . were largely responsible for the prosperity, would be called upon in the future to undertake the great task of simplification and organization and reconstruction, without which that prosperity could not bear its fullest and best fruit." [7]

DISTRIBUTION OF RESPONSIBILITY

Average Far from the Truth. Having directed our attention to the question of responsibility—and everyone, of course, has responsibilities—the question is as to the distribution. The duty of meeting and solving the problems of life rests upon all of us collectively, and it would be easy if we were to assume that the responsibility of an individual were to be determined by dividing the total by the number of people. But all are not of an average dead level of ability. A moment's consideration tells us that men are of different capacities, and therefore some better method must be found than to say that everyone has an average responsibility. In order that the average shall increase or rise, some must be better than the average. There will always be some who are unable to bear the burdens which others can and should bear. It is therefore necessary to find some other method of determining responsibility. Perhaps something like the theoretical idea of the income tax may suggest that democracy demands more than the average from those who have capacity, education and training.

The Engineer's Capacity. If this be the method of measurement, the engineer's responsibility will certainly be greater than that of the average citizen. He is educated in the principles of fundamental science; he is trained in logical thinking; he has been taught to seek the truth at all costs; he knows the difference between demonstration and verbiage; he has learned the value of a fact, even when it is at variance with his interest or desire.

As before stated, the character of his work develops contacts. Public problems are largely of an engineering character; industrial development and transportation decide issues of war or peace; national defense is a technical problem of organization or construction. The

problems of city life have developed out of engineering practices. All of the advance in transportation and other utilities (engineering developments) have made city life *possible,* and it is the same means and the engineer's applied science that must be invoked to make *wholesome* city life *available.*

The Engineer's Fitness. The engineer is particularly fitted to assume this responsibility, and he cannot claim, therefore, to have done his duty when he does only as much as the average citizen. He must take the lead, and recognize this greater responsibility in proportion to his capacity. Opportunities are not lacking for the engineer to fulfill his special duties, if he is willing to recognize the obligation. It is not enough that his work exerts a profound influence on the public welfare. These things create rather than fulfil the obligation.

WHAT THE ENGINEER CAN DO

General. The engineer can prepare to meet his civic responsibility by training himself, as a student, for citizenship. He can develop all sides of his character after graduation. He can constantly keep before him the public character of his work. He can serve the public in official positions wherever opportunity arises. He may help educate the public by writing and speaking, if he has ability. He may enter into the general civic life of the community and associate with those who will be glad to have contact with him.

Student Activities. As a student the engineer should endeavor to understand the real significance of engineering and its relation to community problems, of which we have spoken. He will thus gain an appreciation of the human side of engineering. He should realize that training is for citizenship as well as for engineering. Therein lies the great value of many of the types of co-operative courses. He must, of course, remember that practical experience obtained through these various contacts will be of great future value. The association with fellow workmen, mechanics and artisans and those who have different points of view and varied responsibilities in life and diversified ambitions are all helpful to the development of the student.

This development of the human side will be of special value in the future life of those who come in touch with the rugged emotions of the man who is meeting the difficult problems of life. This question of human responsibility in industry is one of the most trying in

the whole world to-day. It is largely affected by example. H. G. Wells, the historian, says, regarding the devotion of a large and growing proportion of the time and energy of many classes to pleasure and excitement, "This spectacle of amusement and adventure is being brought before the eyes and into the imagination of the working man. . . . In making labor a part of everyone's life and the whole of nobody's life, lies the ultimate solution of our industrial difficulties."[8]

For these reasons and to obtain additional capacity for the enjoyment of finer things in future life, the so-called general or cultural subjects are important in engineering courses—those studies which are the cause of *so much complaint before,* and *so much regret after,* graduation. It is conceivable that a man may be a good engineer with nothing but a technical training, but he never can be a successful citizen or a man in our complex social system without some knowledge of economics and human relations. It is gratifying to note that our educational institutions are taking these questions into account and many of them are placing character, personality and mental ability somewhat in this order in considering applicants for entrance into schools.

Post-Graduate Development. How about after graduation? Talks like these, and comments of elders, indicate to the young graduate that school training alone does not make an engineer. This leads to the very laudable desire (for which credit should be given) to continue study along technical lines. He thus reads scientific periodicals and takes night courses. Just as it was an error before, during school days, so much more is it a grave mistake now to fail to recognize the value of cultural studies and the development of the knowledge of human nature. The young man is wrong again if he fails to continue his reading along broad lines with a sense of obligation for citizenship.

There are many notable examples of men whose lives do not indicate that they devoted entire attention to technical education. One will, perhaps, suffice. George S. Morison, dean of bridge builders during his life, though a Harvard graduate in arts, and once president of the American Society of Civil Engineers, did not take up engineering until four years later, after he had finished a law course and was admitted to the bar. His wonderfully inspiring book, written 20 years ago, entitled "The New Epoch," contains much of

interest to the young engineer. On the last page of this book he says, "In all history and in all periods of the world, the honors are held to belong, not to those who enjoy the results, but to those who have made these results possible." [9]

This remark, coming from so renowned an engineer and so great a student of life, is particularly to be remembered when discussing the last section of our topic relating to "Success."

Opportunities are continually presenting themselves for the engineer to demonstrate his capacity and usefulness as a citizen. His engineering judgment should always be tempered and sobered by the public character of his work. He should remember that the ultimate end is the "use and convenience of man," and not the interesting detail nor ingenuity in engineering design; in other words, his criterion should be, "Does the work pay?"

Engineering Societies. Societies like this provide the fullest and finest opportunities for public service, and for young men to meet with their elders and learn of new developments. Many of the meetings are devoted to the discussion of non-technical subjects. This is particularly true as to the meetings of the Society itself, leaving to the technical sections the discussion of the more intimate details of engineering work. All of this and much more has been accomplished under the able leadership of Chairman Crabtree, of the Publication Committee, now our president. Then there is the Civic Affairs Committee (previously referred to), under the sober guidance of Chairman Khuen, and the Engineering Council of this metropolitan district. All give much opportunity, not only to understand the relationship of public works to society, but also to have brought forcibly to mind the civic responsibility of the engineer himself.

There are many recent examples of the kinds of influence which such societies can have upon public opinion and deliberations. While civic activities of engineering societies are to be highly commended, there should always be unyielding opposition, however, to organized action in the interest or election of designated engineers to public office. Such activity cannot fail to be misunderstood and will undermine the influence which it is so important that these societies exert. Public service, not political preferment, should be the sole aim of such organizations. In these days of unusual clamor and unrest it is doubly important that those who participate and take the lead in such

societies should have clearly ahead the proper goal and aim. What we need in various forms of public discussion is less bigotry and more charity; less egotism and more friendliness; less propaganda and more education; less striving and more service.

There is a fine opportunity for rational discussion of public provisions, and engineers can do much to promote sound thinking and ill-advised action, at the same time fully recognizing the other fellow's right to be heard. In his recent annual address as retiring president of the American Institute of Consulting Engineers, Mr. Charles W. Leavitt said:

> "We all must be ready to give up some of our time to Institute matters, as well as to spend time in helping a brother member or a professional engineer to secure and carry on his work, even if it may mean a sacrifice of our own interests. The Golden Rule applies here, with us who pride ourselves upon being highly educated and highly trained, more than it does with the working classes, among whom, may I venture to say, the sacrifices and help of one to another are more frequently encountered than in higher social life." [10]

Public Activities. What are some of these public activities? It is not sufficient that the engineer analyze public questions for himself and base his action upon sound opinion; the possession of knowledge obligates him to share this with others. Those of less capacity are frequently willing to be misled; some because they are misinformed and lack facts, and some because they do not have ability to use them. The influence of engineers would be greatly extended if more of them would take advantage of opportunities to explain their views publicly by press and platform. The engineer who can supply this deficiency and fails to do so shirks his responsibility. At the same time he must be ready to endure the criticism of many who will misjudge and misinterpret his motives. He may frequently find it said that he is striving for something to his own advantage; or, as is sometimes suggested by competitors who would gladly see one out of the race, "so and so has given up engineering and has gone into politics." But we must have the courage to trust that those who understand him and know best about what he is doing will appreciate his hopes and understand his feeling of obligation as to public service.

It is the engineer's duty to affiliate with some party or political organization and become familiar with the workings of political institutions. The present indications are that the engineer is not so indif-

ferent to his civic and political obligations as was formerly the case. It is very gratifying to find, from a recent analysis, that he measures up well in comparison with the average; but, as stated above, it is not sufficient that he do as well as the average, for he should have a keener sense of responsibility and appreciation of what his duty means.

A recent investigation of the membership of the Engineers' Society of Western Pennsylvania is a single example of one form of political activity, but it is interesting. There are 1288 members of this Society. Of these, 535 live within the city of Pittsburgh; 259 of these, or 48 per cent., registered in September, 1923. Out of the total number, 211, or 39 per cent., voted at the September primaries, and 177, or 33 per cent., voted at the November election. Similarly, for Allegheny County, where there are about 780,000 taxables, a study indicates that while 46 per cent. registered, only 29 per cent. voted at the primaries and 24 per cent. at the November election. The figures for the city of Pittsburgh, covering 453,000 taxables, showed that 53 per cent. registered, 25 per cent. voted at the primaries, and 23 per cent. at the November election.

When one thinks of it, it is extremely surprising that so few people exercise the right of suffrage. Of the 33 United States senators elected last fall, no successful candidate received more than 42 per cent. of the potential vote, and one man was elected by a vote as low as seven per cent. of the total vote at an election at which only eight per cent. was cast. Senator Pepper was elected by 19 per cent., and only 33 per cent. of the total was cast in Pennsylvania.

We evidently need some stepping up of the civic and political activity of the citizenship body. The retiring address of the president of the American Society of Mechanical Engineers contains pertinent information regarding this sort of interest by an engineer. The quotation may not be amiss in this connection:

"Politically, the engineer is weak, because he rather expects his opinion regarding engineering matters to be accepted by the public and by politicians simply because his professional knowledge enables him to speak with assurance. He fails to appreciate that it is not enough to know, to be right, but that he must present his views with vigor and true political wisdom if they are to be adopted.

Because the engineer rarely presses his view on the public or upon the business organizations with which he is associated, he likes to think he is modest. He likes to sit in the background till deference is shown to his

superior technical knowledge by calling him into conference. Too often the reticence he considers modesty springs from lack of confidence in his ability to present his views convincingly; for he commonly knows that he is weak in forensic and political ability. Is it not possible that his modesty is really pride in his technical knowledge and fear that he is unable to enforce his view?" [11]

The same speaker recently said in an educational discussion, referring to public activity of engineers, "Water seeks its level—engineers generally get what they deserve."

It is the duty of every engineer to identify himself with such local organizations as non-professional and business societies and luncheon clubs and take part in their activities. He should become well informed upon the questions of the day and should place his special knowledge and training at the service of those with whom he is thrown into contact and promote the spirit of truth and the formation of public opinion upon the basis of accurate knowledge and sound reasoning.

Most of these things every engineer can do and thus fulfil his share of the obligations to society. All cannot expect to fill high positions and exert the same type of public influence, but the army of society needs good privates, corporals and sergeants, as well as great generals and captains. The criterion by which the engineer, like every other citizen, must be judged is not whether he has contributed, but whether his contribution is according to his ability and whether he has accomplished as much as accords with his capacity for accomplishment. Only then has he fulfilled that responsibility which attaches to his special fitness.

We are, of course, interested in leadership; but we are also interested in ordinary men, and they, too, have a chance of civic service. One of the most important questions of the day is how to bring contentment into the heart of every man in the position in which he finds himself. You notice we say *contentment,* which does not mean *indifference* to one's lot, for the loyal service of assistants is still to be as highly prized as ever. One of the saddest outlooks is that too many young men (ill fitted by capacity and by early training and experience) are trying to become office workers—stiff-shirted, white-collared directors—when they themselves and all society would be better off if they were trained artisans. It is important for people to understand

their limitations and seek contentment within the sphere wherein they find themselves.

DIRECTING PUBLIC OPINION

Reason for Interest. Why are we interested in such a discussion? The answer is that there is a growing apparent lack of interest in the minds of young men who should know and do better, and an indifference among the trained and educated, as to the common affairs of life which go to make up our citizenship. Senator Pepper, at a convention of life insurance presidents a short time after his election, expressed himself as follows, as reported in the *New York Times* of December 9, 1922:

> "Something must be done to impress upon you and such as you the paramount importance of the party primary, or things will not be well with the republic. . . . Schoolmasters tell me that it is extremely difficult to awaken any interest in politics in the minds of the sons of well-to-do fathers these days. . . . Because at home they grow up, for the most part, in an atmosphere of criticism of public men and they witness very little in the way of whole-hearted effort to improve the breed.
>
> And there is a very serious danger that, if this thing continues, the sons of privilege of America will degenerate into little snobs who think themselves too good for politics."

World Sickness. Indications are not wanting that many thinkers and writers are of the opinion that all is not well with the world. As Dr. G. Stanley Hall says, "the world is sick and . . . humanity has entered a very critical stage of its history."[12] Not only the recent war, but the results ensuing therefrom; the menace of distrust and lack of harmony between nations; the wayward and wasted condition of Russia; the marked increase in crime, and disrespect of the law—all contribute to the belief that we are in a most unfortunate and chaotic state of public mind. For this reason, many have the earnest belief that calm thinking and study of the situation is needed in order that we may not go upon the rocks. Theodore Price, in the *Outlook*, says:

> "These glorious opportunities that exist in America . . . are all made possible by a government in the support and administration of which you and I must make ourselves felt if it is to continue. The young men and women of this generation have so long been accustomed to enjoy the advantages of this government that some of them, I fear, have come to regard it,

like the air they breathe, as part of Nature's provision for their welfare, about which they need give themselves no concern.

The result is an unconsciousness of civic responsibility and a lack of national feeling that is lamentable." [13]

WHAT IS SUCCESS?

The following quotation from the aforementioned bulletin of the Federated Association of Engineering Societies, by O. E. Koch, brings us aptly to the discussion of our next topic:

"This co-operation which the engineering profession is now engaged in is not for the benefit of the engineering profession directly, but for the benefit of the public welfare wherever technical knowledge and engineering experiences are involved." [5]

There is, perhaps, nothing more difficult to determine in life than the measure of success. Perhaps college education is regarded as necessary, and provides that type of life which some of us think most successful; yet we must all recognize the fact that some men, whom we have regarded as most successful, have not had the benefit of such education. To-day it is believed that a man is severely handicapped if he does not have such a start.

Recognition of the Engineer. A recent canvass was made by the *New York Times*[14] of the opinions of 27 leading people in the United States supposed to have had the capacity and opportunity to form opinions. They expressed the view as to the 12 greatest men in America to-day, as determined by character, intelligence, executive ability and actual accomplishment: Two named one engineer; six named two engineers; six named three engineers; and nine named four engineers. The average of the replies is three engineers. With all of the other and much older professions to call upon, it is interesting to note that in this case there seems to have been at least one-fourth of the evidence to show that the engineer is foremost in the line of success.

Service Is the Measure. As the "Rotary" motto states, "He profits most who serves best." It is service which counts. The permanent test of greatness is not what did a man accumulate, but was the world different because he lived.

As Price stated it in the *Outlook,* "The men and women of the twentieth century who are most in the public eye . . . are not those

who have accumulated great fortunes, but those who have worked to increase the happiness of mankind and the beauty of the world."[13] Or, as Frank A. Munsey said to the American Bankers' Association, "The living of a life is a serious business. The life that absorbs from the world, gets everything it can out of the world, and gives back nothing to the world, is not worth while. It is a flat waste of human force."

Responsibility Brought by Opportunity. Opportunity is always with us—perhaps now more than ever before, and opportunity exists for scientifically trained men more than for many other types of people. Problems in the future are to be solved with high regard for facts and, therefore, with a real love for service.

We have shown that the engineer has unusual opportunities by training and development, and through his experience and contacts in life. He should reciprocate by giving of these attainments to the service and aid of his fellow-men. He should do this because of his duty to give more than the average. He should do this because out of it comes one of the greatest pleasures of life. Success—not always as measured by his direct emoluments, but certainly as measured by the opinions of those who best know—will come from such human service.

Above all, the engineer must remember that with all of his scientific training and absorption of technical life he must learn how to get along with his fellow-man, to reckon with the human equation, in order that his efforts shall be crowned with that success which comes from a realization of service accomplished. Therein lies the engineer's responsibility.

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DISCUSSION

Mr. Frederick Crabtree:† We have all enjoyed a great treat in listening to the very fine address our retiring president has given us. It covers such a wide field and has such breadth of view and accuracy of delineation that it is hopeless for any one of us to attempt to discuss it in full. I do not know that we are called upon to discuss it, but all of us must have been impressed by very many points that have gone home to us, that have made us think.

Two or three things did come to my mind while Mr. Knowles was talking. The first was the matter of the definition of an engineer. One of the most difficult things a man has to do is to give an accurate definition. Language is so inadequate and our mastery of it so incomplete that one of the most difficult problems an engineer faces is to give an accurate definition of even the most familiar objects; so, naturally, it is difficult to give a really reliable definition of such a broad subject as engineering. I have myself at times ventured to use one a little briefer than the one Mr. Knowles gave, by saying that an engineer is a man who knows the best way to do things—who does things in the best way. That is, of course, not as accurate as the definition quoted by Mr. Knowles, but it always appealed to me as being worth while remembering. An engineer may work out a very elaborate plan, but if it is not the best way it is not good engineering.

Again, my mind ran into a certain current of thought while he was talking with regard to the development of engineering. Of course, as he said, there have been engineers for hundreds, perhaps thousands, of years, especially if you take my own definition. But the engineer had a very limited field until within the past 130 or 140 years. Engineers were either military engineers, like Leonardo da Vinci, or else they dealt with road and bridge building. Those who have read such books as Smiles' "Lives of the Engineers" know that the early engineers he refers to were men who built the roads and bridges in England. Then after Watt invented the steam-engine, and Henry Cort invented the process of puddling, and all the various mechanical inventions came along shortly after that, there was a phenomenally rapid growth of what we now recognize as the various

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branches of mechanical, electrical, chemical and other lines of engineering; but we sometimes fail to remember how rapid that growth was. We are apt to think that engineers have always been with us. How many of us remember, for instance, that it was not until Bessemer invented the Bessemer process for making steel in 1856—and did not get it actually operating until 1858 or 1859—that anybody had ever made at one time a mass of iron or steel larger than 250 pounds. I remember seeing several years ago in Cuba a very large shaft, made of wrought-iron, that had been used for pumping water out of a copper mine. The shaft was made in Scotland, shipped to Cuba and carried over the mountains to the mine; and it weighed several thousand pounds. It was made by welding together in stages many masses of iron. The most that could be got out of a puddling furnace was 150 or 200 or 250 pounds. If they wanted a two- or three-ton shaft they had to weld two balls together, and then make another one by welding two more together, and then weld those two together—to get 600 or 800 pounds. Keeping on in that way, they finally got a big wrought-iron shaft. Yet until quite recently such a procedure had to be followed. The Bessemer process is not yet 65 years old.

And think of the marvelous progress in mechanical engineering and other phases of engineering that has taken place in the last few decades. Life is growing constantly more and more complex. The more complex it grows the more complex and important are becoming the engineering problems, because engineering is the real basis of modern life; and, of course, with greater complexity and with the greater importance of the engineer comes the greater responsibility, as Mr. Knowles has said.

Another thought came to me. Mr. Knowles referred to the desirability of every engineer becoming a member of a political party and taking part in political activity, and he stressed the tendency of engineers to neglect this duty. My mind ran back to our early days in Massachusetts. An instance occurred there about the time we were in the high school. Somebody connected with one of the churches, in that case the Roman Catholic, conceived the idea of training the young men in political activities. He organized a club in which the young men were formed into a city council, with the board of aldermen and the common council, and the boys' council discussed

all the questions that came up before the regular city councils. What was the result of that? Before I was graduated from the Massachusetts Institute of Technology many of the public officials of the city were young men who had had their political training in that school debating society. One of my own classmates was candidate for city treasurer when he was only 22 or 23 years of age. A young man of a later class than mine was elected mayor of the city by the time he was 24 or 25 years of age. Another was president of the common council when he was 24. For years the city was practically controlled by the young men who learned their politics, their knowledge of city management I will say, through that boys' council in that particular church. That is one illustration of what can be done by starting in the right way, and it is a great pity, as Mr. Knowles has said, that more attention is not paid to matters of that kind.

I do not want to weary you with further comment. I would be very glad to have any one else express an appreciation of this fine address.

Mr. J. O. Handy:* When President Crabtree invited discussion of Mr. Knowles' masterly address I am sure that our failure to respond indicated no lack of appreciation, but rather a feeling of inability, at least at the time, to add to a most thorough exposition of all sides of the very timely and important topic which he had chosen. I want first to express my personal appreciation of Mr. Knowles' services to the Engineers' Society of Western Pennsylvania and my admiration for him as the embodiment of the ideal which he holds out for us all—that of active and unselfish service to his fellow-engineers and to the public, who are more and more dependent not only on the fidelity but on the activity of the engineer in their behalf.

Chemists also, many of whom are engaged in the engineering side of chemistry, are feeling more and more strongly their obligation to the public, and are giving, as the engineers are, increasingly of their best thought and work to the advancement of the public interest.

The Engineers' Society of Western Pennsylvania has reason to be proud of the active part it has taken in advocating and executing the vitally necessary improvement of the public water-supply and other matters connected with the public health. It has also taken an

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active part in other public work in Pittsburgh, its most recent work for the city being co-operation between the Civic Affairs Committee and the Zoning Commission. It lent its influence to the effort to establish a down-town branch of the Carnegie Library of Pittsburgh, and that branch is to be shortly established in the City-County Building. The Pittsburgh Section of the American Chemical Society and the Civic Club of Allegheny County also worked to that end. I look forward to more and more unselfish activity on behalf of individual members of our group for the advancement of the common welfare in Pittsburgh, in Pennsylvania and in the nation. I feel especially confident that Mr. Knowles will be called on with increasing frequency for important services in public life and that he deserves such recognition and distinction.

SOME VIEWS ON THE RAILROAD SITUATION*

By Elisha Lee†

It is an unusual pleasure and privilege to be with you to-night, partly because I am myself a member of the engineering profession, and partly because engineers are peculiarly fitted to grasp railroad facts and problems with ready and sympathetic understanding. American railroads, regarded as a national transportation system, constitute probably the finest monument in the world to engineering genius and knowledge, as well as to the foresight and courage of business men, financiers and investors. Indeed, the physical form which our railroad plant takes to-day is almost wholly the work of engineering brains, chiefly in the civil and mechanical branches, although our specialists in electricity and chemistry may also claim important shares.

The era in which we are living is chiefly distinguished by the marvelous advancements which have been made, especially during the last fifty years, in the practical applications of science to economic ends. As such, it may be differentiated from all other periods in history as the "Age of Engineering," for engineering may be defined as the utilization of progress in theoretical science to the material improvement of the standards and conditions of human life.

I am exceedingly proud of my membership in this great profession, the contributions of which to the betterment of our race have certainly not been excelled, and perhaps have not been equaled, by those of any other secular calling; and I am especially proud of the fact that ever since my graduation as a civil engineer, 31 years ago, I have had opportunity to apply my technical training to the indispensable public service of railroad transportation.

Never before have I felt that pride so keenly as at present. Since the earliest days the railroads have always been splendidly efficient servants of our country. They were the principal physical means by which the interior of the continent was opened to settlement and civilization. Following their emergence from the experimental stage, some ninety years ago, their evolution has paved the way for the development of our immense agricultural wealth, our great cities, our

*Presented at Annual Banquet, January 28, 1921.
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countless factories and mines, and finally for the perfecting of our American system of industrial mass production which is the real basis upon which our economic world leadership rests.

After passing through a prolonged era of misunderstanding, misrepresentation and political abuse, which we may call the "Dark Ages" of transportation history, our railroads at the present time stand far higher and better in the public estimation than for more than a generation. They have won the public respect, and won it fairly. They have been given the cleanest bill of health of any department of American business enterprise, following nearly forty years of the most searching investigation and microscopic flaw hunting to which any form of business has ever been subjected in any country.

The American railroad systems, as they stand to-day, represent an investment in physical facilities of roundly $22,000,000,000. It may be recalled that in 1920 the Interstate Commerce Commission allowed a tentative valuation for rate-making purposes of $18,900,000,000, as against a book figure, for property investment, of $20,040,000,000, at the opening of that year. Since that time, at least $2,300,000,000 more have been expended upon capital improvements. This would bring the present valuation, based on the Commission's tentative figure of 1920, up to $21,200,000,000, and based upon the book figures of the companies, as they stood at the opening of 1920, up to $22,340,000,000.

Were they to be valued on the basis of present prices of materials, the actual market worth of real estate and the prevailing costs of labor and wages, a figure at least half as great again would inevitably be reached. It is indeed questionable whether our railroad systems could be duplicated to-day for $35,000,000,000 to $40,000,000,000.

It may be of interest in connection with this subject of physical valuation and property investment to turn for a moment to the annual pay-roll of our American railroads, which we may perhaps find it useful to regard as a continuing investment in the loyalty, fidelity, devotion and enthusiasm of an immense working force. The $22,000,000,000 physical plant of American railroads has been nearly a century in the making, representing an investment of considerably less than $240,000,000 for each year of growth. But last year the employees of these railroads received $3,000,000,000 in wages. In other words, in about the next six years, allowing for the probable

increase in forces, the railroads of the United States will make an investment in pay-roll that will duplicate the investment in plant which has had ninety odd years to pile up. So we can see that it is really a matter of nation-wide concern that this vast pay-roll investment in human service and loyalty, which is growing at the rate of $10,000,000 or more a day, should be made with wisdom, in order to produce the vastly beneficial results which are capable of realization under intelligent and sympathetic relationships between railroad managements and railroad working forces.

This brings me to the point where I wish to say something in regard to the relation of the engineer to labor problems. The engineer in our present industrial system generally occupies a leading position in what we commonly refer to as "management." He is intrusted with the determination of policies for successfully guiding and directing the work of large numbers of men. He is in turn responsible for creating and maintaining an output satisfactory as to quantity, quality, and cost per unit, and, in the case of public utilities, for continuity and safety of operation.

Necessarily, these responsibilities include the building up and holding together of a working force, adequate, but not excessive, in numbers, loyal and willing in spirit, and capable of maintaining a satisfactory rate of production. This means that the engineer must not only devise labor and operating policies which are sound on paper, but must convince his working forces of their reasonableness and fairness. From this viewpoint, part of the engineer's equipment is, or should be, an adequate understanding of human nature, and a real knowledge of the causes which contribute to labor unrest or contentment.

At present, and for some time back, the engineer, confronted with the problems which I have endeavored to sketch, has been obliged to cope with practically a universal demand for lower unit costs. The people want, and in some cases are insistently demanding, lower prices for manufactured articles and commodities, and lower rates for service. It is hardly necessary for me to say that this expectation cannot be realized unless we can find some means of effecting lower labor costs, and I may say that as matters now stand, increased output per man, either by greater personal efficiency or by engineering aid, holds much brighter hope for increased efficiency than lies in any possible

revision of wage scales. Such increased output means no impairment whatever of our American standards of living, which, I am proud to say, are the highest of all time and of any nation.

This necessity for lessened labor costs arises from the fact that labor is the largest individual item entering into costs. In the case of the railroads, their own pay-rolls constitute about 50 per cent. of the total cost of operation; and fuel and material costs, which make up nearly all the other expenses, are in themselves largely wages paid to other workers. The main problem in reducing costs, whether of products or services, lies, therefore, in obtaining the co-operation of labor.

This problem lies chiefly in strengthening in the individual worker the sense of loyalty to his job and to the enterprise by which he gains his livelihood. This problem with the railroad is largely an inheritance from the period of government operation. It is associated with the policy of adjusting wages and working conditions for war purposes and political ends which largely prevailed during the World War. It also reflects other policies of government control which resulted in forcing large bodies of railroad workers under the sway of those labor organizations which practice or countenance the uneconomical and indefensible principles of the sympathetic strike, limitation of output, and the closed shop. In this connection, I might say that these principles are not countenanced by the four big transportation brotherhoods.

While, according to historians, strikes and other concerted labor movements to obtain more satisfactory working arrangements were not unusual from about 2000 B. C. up to modern times in the old country, in our own country the condition of labor unrest did not assume definite form until the early part of the nineteenth century, and was of no particular importance in our economic life until about the outbreak of the Civil War. Since that time the matter of unrest among laboring men has grown in a manner corresponding rather closely to the growth of the so-called factory system of industry, where capital, management and labor are rather distinct individual groups.

It will be recalled that, up to about the beginning of the nineteenth century, industrial plants were small, and the owner was not only the capitalist, but also manager and often one of the workmen

Therefore, these conditions of employment constituting an intimate relationship between management and men, deserve serious consideration in determining the policy for the handling of men under our present industrial system.

I feel that we are often very much misled by considering the expressed demands involved in concerted labor movements, rather than the underlying cause for these demands. It is, for instance, a rather popular idea that the predominating cause of strikes is a desire for increased wages. As a matter of fact, the element of wages is, certainly in a very large percentage of strikes, only injected after the organization has been completed and functioning for some time. Many strikes are called without any mention of wages at all. There is a deeper cause than either wages or hours of labor, or even many of the demands calculated to improve working conditions. I believe the chief underlying cause of labor unrest making itself felt in the form of labor unions or other concerted labor movements is the human desire to have an unoppressed voice in all deliberations where labor policies are involved.

These human and proper desires of labor are generally met by some form of collective bargaining. It probably represents the only practicable basis by which the labor relationships of large masses of workers can be dealt with and adjusted. The thing is to distinguish between collective bargaining and collective coercion. Unfortunately, we have a good deal of the latter; so much so that certain large and important groups of workers outside of the railroads have been able to retain, in practical entirety, the highest inflated wage scales which prevailed during the World War. We must cure that condition by a process of education, and by directing the pressure of public opinion against the attitude of those groups of workers who persist in substituting coercion for bargaining in their collective relations with society. There have been many experiments evolved to meet this situation in the form of working arrangements commonly referred to as "employee representation." We have one form on our railroad. Many of you have heard of it, and I will not attempt to explain its details. Essentially it is a system of collective bargaining without our own ranks—a plan by which our officers and men get together face to face to avoid or settle, in peaceful conference, difficulties which may arise respecting wages, discipline, working conditions, and similar matters. It

recognizes the right of the worker to a voice in determining questions affecting his own conditions of employment. It not only recognizes the general principles of collective bargaining, but is in itself a working system of collective bargaining, which simply means dealing through chosen representatives instead of individually with each employee. It seeks to avoid controversies and to assure employment at fair pay. It is in no sense anti-union, the truth of which statement is evident from the fact that in many cases the representatives elected under it continue to hold their union affiliations. No man on the Pennsylvania Railroad holds or loses a job because of union affiliation or non-affiliation. The plan may not be perfect, as yet, but has the support of an overwhelming majority of our employees, expressed in the results of elections held under secret ballot.

We have found that the elected representatives when placed on their responsibilities as judges, with the same individual voting power as the management, have proved themselves honest, thoughtful and practical, and are taking a greater interest in and helping to solve some of the problems of management. It is working with greater success every day, because, as we believe, it is based upon fundamentally sound principles. Some time we hope to see the power and influence of the government exerted toward helping, instead of hindering, the functioning of this obviously American plan of settling differences peacefully and by mutual conference. A vast forward impetus would thereby be given to restoring and further strengthening the feeling of loyalty on the part of railroad workers, not only on the Pennsylvania, but on other lines as well. These are some of the problems that engineers must continue to study, for none is of more importance to-day than those of human relations in industry. That a proper solution will be worked out to fit the varying cases I have no doubt.

To an audience of engineers it would be superfluous to demonstrate the indispensable character of the public services which our railroad systems render. The pursuit of almost any branch of our profession will bring fresh proofs of that truth daily. I may say that the business men of the country are also alive to the necessity for good and progressive railroads, and I believe the vast majority of intelligent and progressive farmers also.

Our railroads are more open to the scrutiny of the public to-day

than any other form of business. They have no longer any secrets. I do admit that they have some grave problems which will require courage and intelligence to face and solve. But I am happy to count myself among those who view the outcome hopefully and with sober confidence. My reasons are very simple. The railroads are indispensable to the country. Continued national progress is impossible unless they are allowed to grow and prosper. These facts are better known than ever before and are gaining a wider recognition every day. I have great respect for the common-sense of my fellow-citizens and refuse to believe that, in the light of their broader knowledge, they will indefinitely keep on permitting such invaluable national assets as our railroads to be misused for political ends or despoiled for narrow and selfish motives. Hence, I look for a better deal at the hands of politics and for continued improvement in the character and purposes of public regulation. It is possible for regulation to be a splendidly helpful and constructive force. I believe it is in process of so developing and will reach the goal.

Just a brief reminder of the excellent performance of the American railroads in the past eight or nine months, during which time they placed their road and equipment in good condition, and carried a record-breaking traffic practically without embargo or car shortage. This has been accomplished by the managements with the co-operation of the employees and the shippers. I heartily congratulate the railroad profession as a whole on the loyalty and improved efficiency of the employees during the year 1923, and for their steadfastness to the public service in avoiding strikes. These results should be convincing evidence that if railroad managements are allowed greater freedom to deal promptly with all problems, including those of rates and wages; and are freed from further restrictive laws and vexatious and useless inquiries—which waste time, money, and effort that could be better spent on the problems of management—they can produce a transportation service equal to the demands of the American people.

AMERICA'S ATTITUDE TOWARD EUROPE*

By Fred I. Kent†

America sees Europe from many angles. There is the care-free tourist who runs about from place to place over the beaten track, picking up here and there perhaps something of ancient coloring, but obtaining no conception whatsoever of contemporaneous history. Then there is the man of business who meets those with whom he would deal and who is naturally influenced by such success as he may have in developing his own particular undertakings and who reflects the conditions which he finds prevailing in his trade or industry. In between these two classes are those belonging to each who go out of their way to study conditions as they may exist, but who are entirely without adequate facilities for getting at the bottom of things. There are also two classes of lawmakers who make European circuits—those who desire to know the facts, and those who wish to obtain some local color to back up their pet theories. It is difficult for any lawmaker to obtain a clear idea of any foreign country which may be having friction with its neighbors, as the instincts of self-protection tinge every statement made to him. Even so, such trips taken with honest intent have great educational value and can result in much good. Added to all these is a comparatively small number of men who can take the time and who have the entrée necessary to enable them to meet a sufficiently large number of men, in government and out, and extending into many walks of life, to make possible some real understanding of that which they may be seeking.

Unfortunately, the positiveness of those with superficial knowledge is often as great as that of the men who may have had real opportunities to obtain a clear idea of conditions; but, after all, a composite opinion of many observers is essential to a comprehension of any foreign people. With the exception of the demagogue, who colors what he may have seen to meet his own desires, the reactions of all men of intelligence who may have traveled in Europe carry within them something of value, and it is from the writings, speeches, and conversations of them all that the attitude of America toward Europe is

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determined from time to time; but it must be admitted that to-day that attitude would seem to carry too much of criticism and too little of understanding.

To obtain peace after discord has arisen between human beings, the same things are essential whether the friction has occurred in a family, between families or communities, between different sections of the same country, or between different countries. Differences between men develop primarily from two causes—misunderstanding or selfishness. There is, however, much the same development from disagreements which have been brought about from either cause, as anger and hatred soon begin to play their part. When anger and hatred are allowed to grow sufficiently before they are controlled through the application of intelligence, war is certain to occur whether it be within families, or between communities, states, or countries. As soon as a state of war becomes existent, the exercise of anger and hatred becomes predominant, and then a certain degree of exhaustion of either one or both sides to the controversy must occur before reason can resume its sway. At such a moment, progress toward peaceful conditions is dependent upon the rapidity with which anger and hatred are eliminated, and such rapidity is in itself more or less dependent upon the severity of the conflict.

Criticism, and particularly unfair criticism, arouses in men opposition, anger, and if carried far enough, hatred, and, consequently, its use after war inevitably delays the peace that is being striven for and, when the exhaustion of the contestants is not too great, it often leads to further strife. If, therefore, America would be helpful in bringing about the restoration of peace in Europe, we must clear our minds of criticism and confine our efforts to constructive thought. That this is difficult, even for America, is partly due to the effect of the war strain upon the mentality of our own people, which is evidenced in much the same way as in Europe, but possibly in different degree.

For instance, abnormal waves of crime abound in both Europe and America. Governments in the countries of Europe and in America have been hampered by selfish minorities, which have attained power by capitalizing the discontent resulting from war, which inevitably affects different groups of men with different degrees of severity.

Men know that consistent progress can be made only by allow-

ing majority opinion to prevail, but with full protection to minorities, until people can learn from experience how to take the next step. The breaking up of legislative bodies into various groups representing special interests only, and not those of the people as a whole, blocks progress and is certain to result in harmful compromise legislation.

One of the greatest brakes upon progress toward peace in Europe is the lack of individual legislative power of majority parties because of the great number of minority parties, which are for themselves and not for their countries, and which are ready to cast their strength wherever they believe that it may be most harmful to the parties in power, regardless of results.

In the United States exactly the same situation prevails, although there is no honestly elected third minority party in sufficient force to hold up legislation. The same evil has been developed, however, through the action of certain men, who have been elected by the votes of one party, in being willing to betray that party to the party in opposition in order to acquire force and influence which is not within their right.

It is not a question as to whether the principal minority party would undertake activities which might be harmful to the country under such circumstances that makes such action reprehensible, but the fact that the will of the people as expressed at the polls has been deliberately defeated by those elected to carry it out. For instance, no one can believe that Republican Iowa would vote for a Democratic chairman of the Committee on Interstate Commerce.

We can plainly see, therefore, that in our own America we have for the moment degenerated into a most unfortunate legislative position that is as much of a hindrance to progress here as the same conditions which prevail in Europe. It was because of the development of such a condition in the Italian parliament that a Mussolini was necessary, and, when men will not allow a majority government to act while it is in power, it is a direct encouragement to autocracy and a consequent depreciation of democracy. If, therefore, we would understand clearly why the governments of Europe can move only slowly toward reconstruction, we can find the answer by studying the present conditions which exist in our own Congress. Such a situation could develop only through the exercise of the same spirit which

induces war, and in reality it partly represents something of that spirit which has been left over from the great World War, exactly as is true in Europe.

Then again, the hatreds which prevail in Europe are constantly being held up before us as a reason why we should hold ourselves aloof from Europe, regardless of how it may affect our own interests. Is there any quality in such hatreds different from those which men in the United States are endeavoring to arouse between various sections of the country and between groups who may be earning their livelihood in different ways and between those whose success in life has been made and those who have it still to make? Is there any more justice in teaching envy and hatred in the United States, instead of trying to develop co-operation for the benefit of all, than for the same thing to be going on in European countries? In view of our prosperity and lack of real need, are we not possibly more to blame as a people for allowing leaders with false intent to obtain power by giving them our support when their every promise, if it could be carried out, would be unfair, than those in European nations who do precisely the same thing in their mistaken efforts to lift themselves out from under the terrible strain to which they have been subjected by the World War and its aftermath?

Until we can put our own house in order, we are in no position to criticize the peoples of any country, but, even if we were justified in doing so, it would accomplish nothing. Of what avail is it, for instance, to criticize the action of France for not having yet arranged for payment of her indebtedness to us, and what right have we to do so? Officials of the French government have never suggested any repudiation of the indebtedness, but they have claimed their inability to determine just how and when payments could be made to us before they know how and when Germany is to pay France.

In order for France to pay the United States she must be in position to accumulate foreign exchange, and she is thoroughly aware of the fact that her ability to do so is going to be affected by the amount of reparations which she receives and the methods under which payment is to be made. It would not be fair to the French people, or fair to the United States, to fund the indebtedness on any basis which could not be carried out; and what right have we to criticize her for loaning francs to other nations when she believes that

by so doing she is conserving her own position, which, in the opinion of her government, will enable payment to us sooner than would otherwise be true? The loans which France has made to the central countries of Europe have been in francs, which have been spent in France in ways that have given employment to Frenchmen and that have served two purposes—one, to build a barrier between Russia and Germany, which has been felt necessary in the interests of the French people; and another, to secure an asset in return for money spent to keep Frenchmen employed. Is not the French government going to be in a better position on account of having its people employed and in having an asset in the obligation of other governments, representing the cost of such employment, than if it paid the same amounts to unemployed Frenchmen for doing nothing? Is it not of far greater benefit for men to be paid for working than to be paid for not working, and is not such action going to result in the maintenance of the French power of production (upon which she must depend to pay the United States) to a greater extent than if her people degenerate through idleness? But regardless of any opinions to the contrary, how can criticism of France, while her people are under their present strain, accomplish anything except further delay in the settlement of the European difficulties?

The natural impatience of Americans has also resulted in criticism that is unwarranted. Only the passage of time can quiet mentalities which have broken under the stress of war, and the lash of criticism can hinder, but it cannot help, recovery. Merely because we can cover in one evening's reading years of history does not mean that we can live history except day by day, and impatience with slowly moving developments is not going to change this fact.

If it had not been for the Federal Reserve system, it is difficult to conceive how the United States could have met the economic difficulties developed by the World War without serious monetary disturbances. After the armistice and during the time when many countries were endeavoring to replace commodities which had been destroyed during the war and prices consequently began to mount, the Federal Reserve Board and the Federal Reserve banks were thoroughly alive to the fact that a serious break in prices was certain to follow. In order to prevent too great a disaster at such time, Federal Reserve officials gave warnings which resulted in the slowing up of

inflation and which undoubtedly saved numberless individuals, firms and corporations from bankruptcy.

During the rise in prices of commodities, land values went up as well. Farmers were naturally led into land speculation, as prices of commodities were so high that productive land seemed cheap at almost any price. Farmers, being able to borrow without difficulty, bought land at higher and higher prices. When inflation was stopped, those who had purchased at the high prevailing prices, which were far out of line with real values, found themselves in debt and with land which represented large losses. If the Federal Reserve system had allowed the inflation to go further, the buyers of land would have found themselves in exactly the same position, except that their losses would have been much greater. We then had the spectacle of men decrying the Federal Reserve system because its action had prevented the farmers from losing more than they actually did lose, and in an attempt being made to turn our great banking organization into a political machine.

How far removed are we from one phase of the intolerance of Russia when our Senate attempts an investigation of what is termed propaganda aimed to develop public opinion in the United States? Is it not the right of every American citizen to express his ideas as to what he may believe to be to the best interest of our people and to endeavor to obtain the support of his fellow-citizens in every legitimate way? Is it not clearly his duty to do so, and is it not through the exchange of ideas that men are enabled to make progress in civilization?

The preaching of sedition and attempts to overthrow government for the purpose of seizing power for the use of those who hope to profit by it is an entirely different matter and is reprehensible and against the law. But men who openly strive to obtain a verdict from their fellow-citizens as to the advisability of carrying out certain policies in which they believe, are only doing their duty as citizens. It is solely through such means that the vast majority of people have an opportunity to consider questions which it may be necessary for them to solve. If propaganda is to be open only to those forces for evil which work surreptitiously, this country will certainly retrograde until it meets with some disaster sufficiently great to bring its people back to their senses. This whole situation requires recognition rather

than criticism, for it is unquestionably only a phase of the disturbed mentality which has been brought about in all peoples because of war.

Regardless of war, has our progress been free from the influence of the weaknesses of humanity? Some years ago, men of unusual vision took huge risks and built railroads through territories which would have resulted in tremendous losses to them had they misjudged the situation. Such vision materialized made it possible for other men to develop their own lives in ways that would otherwise have been impossible. But a time came when the interests of the people required and could properly demand certain changes and certain control of railway methods. Instead of orderly progress being made in such development, certain men began feathering their own nests by plucking the railroads, and it must be acknowledged that there are many such men still at work at great cost to the public. Instead of our having the intelligence to make readjustments in methods of business control as the public interests demand them, we allow men to profit by criticism of their fellows when no wrong has intentionally been done, but where the need for a change in methods has been brought about because what was started as a private matter has developed into something of public interest.

The rapid growth of population in the United States has resulted in such quick changes in conditions in many lines of business that methods which have been entirely honorable and proper have suddenly been found to be unfair. It does not seem possible for men to anticipate such unfairness, but instead they must run into a condition where it actually exists before they see it. This does not mean that those in control of the businesses affected have been intentionally unfair, nor that, when they have carried on their life work with honesty and integrity and have made it possible for many other men with less ability to make their living and provide for their families, they should be subjected to the vile criticisms which have been cast upon them by those human leeches who are willing to live off their fellows. Many a high-minded American who has spent his time and energy in building up a great business, which has been of great benefit to his fellow-men, has been broken in spirit in his later years through false criticism. It is a pity that we cannot make progress through impersonal consideration of the problems which arise from the standpoint of public policy, but it seems as though men were not yet able

to make their way without trampling upon other men. This is one of the great faults of humanity and, until we recognize its existence, we will never be able to correct it.

It can hardly be expected that men who find that they can win applause by crying out against the weaknesses of other men can be led to change their ways unless the public first sees the error of its way. Those of us who are not in government positions should therefore do everything within our power to let those who are in official service, in whatever capacity they may serve, realize that, while they will have our confidence in every constructive undertaking and our consideration when they make minor errors of judgment, we will resent any step which is clearly taken for vote-getting purposes by playing upon the passions of men to their detriment. Our public has become so accustomed to condoning statements brazenly made by our public men—which clearly show entire disrespect of public opinion and really carry within them insult to the American people—that all sense of decency in public utterance seems to have been abandoned.

But is it necessary for us to carry such a system into our dealings with other nations? Can we not eliminate personalities in our study of international problems and give these problems that cool consideration which is so essential to their solution?

The fact that some of the difficulties in Europe are based upon jealousy, hatreds, and misunderstandings must be recognized, but that makes it all the more important that our relation to the situation should be one of impersonal consideration, and those in the public eye who do nothing but criticize should be given to understand by the people that their methods do not meet with approval. Our international relations should not be made the foot-ball of politics. This will continue, however, just so long as our people see fit to applaud those who do it.

It is strange how rapidly we forget. In the spring of 1920, business in the United States was booming, we were importing from many countries of the world and exporting to Europe. All of a sudden, Europe stopped buying because her credit was temporarily exhausted. As a result, there was a tremendous fall in prices, but this fall in prices in itself was not the worst phase of the situation, as it was the utter stagnation in markets which caused the most serious trouble and

resulted in the so-called frozen loans, many of which have not been liquidated to this day.

Should the conditions in Europe, with their potentialities for trouble, so develop as to bring about another sudden stoppage in European buying, we would be confronted with a situation similar to that which occurred in the fall of 1920; and, while the drop in prices as they exist at present would not be as great, yet we might meet with the same stagnation in markets. While, after 1920, we worked out of this situation rapidly, because the buying power of Europe came back fairly fast, any new development there which would be serious enough to cause a similar phenomenon based on the different conditions which exist in Europe to-day could not be expected to work out so quickly. It is over such an uncertainty that we are living to-day; and, while progress is actually being made toward a settlement in Europe, it is only in conjunction with developing militarism that must either be controlled or lead directly into another war. Whatever else history may have told us, it has clearly said that this proposition is inevitable. If militarism in Europe is allowed to continue, therefore, we can hardly hope to escape a new war merely through finding a method of re-establishing the finances of Germany, even if it is found possible at the same time to work out some settlement of the reparations. If, therefore, there is open to the United States any legitimate method by means of which it can develop a military disarmament conference in Europe, it is clearly our duty to undertake it.

Accepting conditions as they exist, it is clear that it is not within the power of any one European nation to reduce its military forces unless all of the other nations do so as well. Furthermore, it cannot be expected that any general disarmament can be brought about unless some force can be introduced to start it with the recognition of all those concerned. The question is whether there is any such force and, if there is, how can it be exercised.

The strongest desire of all the peoples of Europe is to have the reparations question settled. It is just here that the force of American public opinion, which would positively demand the stoppage of militarism in Europe before it would consider any readjustment of the interallied indebtedness, can be brought into play.

The financial condition of France is such that she does not feel that she can afford to accept from Germany any reparations agree-

ment which does not carry with it payment to France of a sum sufficient to meet her requirements for reparations, and also such amounts as she may be obliged to pay to Great Britain and the United States in settlement of the interallied indebtedness. If, therefore, there is some basis of funding the interallied indebtedness that could be undertaken by the three creditor nations—Great Britain, France and the United States—which would result in such a readjustment of the interallied indebtedness, that its total when added to the reparations would not exceed a figure that it is felt that Germany can pay, such a method of funding, if made effective, would then enable the settlement of the reparations. But if the people of the United States were unwilling to consider any readjustment of the interallied indebtedness unless militarism were stopped in Europe, such an arrangement could not be put in force except in conjunction with a military disarmament conference which could be made effective at the same time. It would seem, therefore, as though an opportunity to bring about such a conference clearly exists and that it should be taken advantage of before it is too late.

The committee which is now acting in an expert capacity under the Reparations Commission is engaged in finding a means of rehabilitating Germany, but it has no power to consider the interallied indebtedness, and properly should not have. Our government has taken the position that reparations and the interallied indebtedness should be considered separately, and this is undoubtedly wise for many reasons. But it would be entirely in line with the attitude which has been taken by our government for the Debt Funding Commission to enter into negotiations with the other creditor nations for the purpose of ascertaining what method of funding the whole interallied indebtedness would enable a settlement of the reparations, and whether the nations of Europe could be brought into a military disarmament conference aimed to bring about such parliamentary action as might be necessary to reduce their military to a national police.

It is just as vital to the neutral nations of Europe that the reparations question be settled as it is to the allied nations, and there is reason to believe that, if the debtor nations of Europe would agree to a plan of disarmament, the neutral nations would join with them.

With the reparations settled and peace restored in Europe, such destructive forces as exist in the Russian government would lose their

power, as the discontent upon which they depend for their success would be eliminated. Russia would then become so dependent for her own progress upon the good-will of other nations that she could be expected to join with them in such military agreements as might be undertaken.

Should the Debt Funding Commission enter into such negotiations, it would not lead to the entanglement of America in European affairs in any manner whatsoever. Should such negotiations fail, no possible harm would be done and the position of the United States as regards the whole situation would remain unchanged. On the other hand, if the Debt Funding Commission through such negotiations should succeed in coming into an agreement with the nations of Europe as to a method that could be used to bring about a final settlement of the reparations and to obtain agreements that would stop militarism in Europe, the people of the United States would be in a position to consider the proposition intelligently and to accept it or reject it as they might believe to be to their best interests.

No one in America can to-day assume any attitude toward the interallied indebtedness based on knowledge as to the forces for peace which lie within it and it would seem as though the time is fast approaching when we should be in position to do so, or such opportunity as may exist will be lost. In spite of the criticism, the impatience, and the lack of understanding of Europe on the part of many in America, the spirit of our people is so fine and their sympathy for those in distress is so real that they can be depended upon to do the right thing when opportunity offers.

After all, a wonderful people has grown up in America and, while we must admit our faults if we would correct them, nevertheless our progress has been consistent and we can well be proud of the part we have played in history. The great guiding principles under which we have developed were provided for us by those of our forefathers who wrote the constitution of the United States. When we would have gone wrong, those principles have saved and protected us, and they must be preserved inviolate through these troublous times while the minds of men are recovering from the strain of the strife of war.

And what of our attitude toward Europe? Can you not feel underneath the surface of the superficial a great movement of desire

to be helpful, an acknowledgment to ourselves of our own need for a world of peace and a great willingness to do our part when it is clearly shown what that part may be, freed from ties that might bind us contrary to our principles and traditions? Even as we may have faith in the high purpose of our people, so may the nations of Europe hope for our sincere co-operation in their every effort to restore peace to a war-stricken world.

SOLUTION OF THE TRANSPORTATION, PARKING AND FLOOD PROBLEMS OF PITTSBURGH*

By E. K. Morse†

This paper will be confined to what is known as the "central business district" of Pittsburgh.

Location. The business section of the city is best defined by indicating its location as that portion of the city included between the east line of Tenth Street and Grant Street projected and the United States harbor lines of the Monongahela and Allegheny Rivers as now located. This area contains a total of 218 acres. It is interesting to note in this connection that the business section of the city of Chicago contains 600 acres; that the city of Philadelphia contains 1400 acres; that the city of New York to Forty-second Street contains 4000 acres; that the city of Boston contains 1900 acres. The topography of the immediate vicinity in conjunction with the Monongahela and Allegheny Rivers forms an acute angle at the Point, into which all of the street-car, vehicular and pedestrian travel wedges itself until, during the rush hours of the morning and evening, the conditions are intolerable.

Character of Traffic. The traffic entering this central business district is composed of street-cars, automobiles, trucks and horse-drawn vehicles and pedestrians. Between the hours of 5 and 6 p.m., during the month of November last, there was an average of 557 street-cars and 171 trailers passing into and out of this congested area. A count made by the City Planning Commission, December 13, 1923, gives the maximum number of automobiles within this district at 2 p.m. as 6656, the number entering at 41,485, and the number leaving at 41,039, or a total of 82,542 between the hours of 7 a.m. and 6:15 p.m. It is believed that the total number of foot passengers coming into and passing out of this same area amounts to at least 120,000 daily.

Congestion. The stranger wonders how it is that the citizens of Pittsburgh can transact the volume of business that is daily accomplished. Is it to be wondered at that more than 12 large automobile associations east and west of our city, during the year 1923, warned their members to avoid Pittsburgh and the Pittsburgh district in their

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motoring east and west? When Second Avenue was opened and the Boulevard of the Allies was turned over to travel, it was believed it would provide a relief to the congestion in this city for considerable time to come. The recent count made by the city shows that the total automobile and truck travel on Bigelow Boulevard and the Boulevard of the Allies from 7 a.m. until 6:15 p.m. was as follows:

	Inbound	Outbound
Bigelow Boulevard	7971	7435
Boulevard of the Allies	4565	4822

These figures show that the travel on the Boulevard of the Allies in its unfinished condition is already nearly 60 per cent. of that on Bigelow Boulevard. It is apparent that the relief of our traffic conditions is far from being established.

Relief from Congestion. The question naturally arises as to what will give relief. What will reduce the congestion, and is the solution a financial possibility? There is a solution, and a comparatively simple one, but it means the co-operation of our city and the United States government to make it complete. The first step is to relocate and re-establish the United States harbor line from Grant Street on the Monongahela River to Tenth Street on the Allegheny River and, on this established harbor line, build city walls from Grant Street on the Monongahela River to the Point and from the Point to Tenth Street on the Allegheny River. These walls should at no place be less than 250 feet from the building line of Water Street and Duquesne Way. They should be built to the flood height of our record flood of March, 1907, and filled out level and, at such points along Water Street and Duquesne Way as were flooded at that time, should be raised to the level of the established walls. It is further proposed that a wharf wall be built on the North Side extending from the abutments of the Fort Wayne Railroad bridge across the Allegheny River to a point down the Ohio River as far as Manhattan Street extended, and of practically the same height as the walls proposed along Water Street and Duquesne Way.

River Walls. The location and height of such a wall were approved by the Flood Commission of Pittsburgh in its printed report published in the year 1911. This report was compiled and written by local engineers and is accepted as the best information published on this subject.

Area Reclaimed. If such a wall were constructed along the lines contemplated in the plans now made, the total area reclaimed—from the building line on Water Street to the face of the wall along the Monongahela River and the building line on Duquesne Way to the face of the wall along the Allegheny River—would be about 59 acres. The amount of ground reclaimed adds 27 per cent. to the present total area of 218 acres in the central business district. Our present street area is about 10 per cent. less than the average of practically all the cities comparable with ours.

With a city congested as Pittsburgh is, it seems incredible that the Point should be occupied by storage buildings, warehouses and freight depots. The property is worth too much to be used for such purposes. The holdings of the Pennsylvania Railroad at the Point are about 11 acres. It is hoped a trade can be made, between the city and the Pennsylvania Railroad, which will bring about the removal of the elevated tracks from Duquesne Way and turn over the 11 acres for mercantile uses. If that were brought about, the city would then have 70 acres for city planning. If the Pennsylvania Railroad be removed from the Point and Duquesne Way and the proposed improvements made, the whole of that part of the city below Ferry and Stanwix Streets will be rebuilt, and the ground value be very greatly increased. In order to bring to a proper completion the wharf improvement, Grant Street should be widened to 80 feet and extended through the Pennsylvania Railroad yards to Liberty Avenue. Strawberry Alley should be widened. The Pennsylvania Railroad should be asked to donate enough ground to the city on Eleventh Street and on Penn Avenue from Eleventh to Tenth, on Tenth Street from Penn Avenue to the Allegheny wharf, and on Seventh Avenue from Bigelow Boulevard to Grant Street, to make all these streets 80 feet wide and extend Grant Street through the Pennsylvania Railroad yards to Liberty Avenue. A viaduct should be opened through from Bigelow Boulevard to connect with the proposed Liberty Bridge. Stanwix Street should be widened to 80 feet. If the wharves are improved as outlined, a better plan of street widening and extension would be to extend Grant Street 80 feet wide through the Pennsylvania Railroad property to Liberty Avenue and, from the intersection of these two streets, lay out a new 80-foot street through the Pennsylvania Railroad yards to Tenth Street and Duquesne Way and vacate Tenth

Street from Penn Avenue to Duquesne Way. Liberty Avenue and all cross streets and alleys between Liberty and Penn Avenues should be vacated from Eleventh Street to Thirtieth Street and become the property of the Pennsylvania Railroad for freight yards. Penn Avenue should be widened to 120 feet from Eleventh to Seventeenth Street, 100 feet from Seventeenth to Twenty-eighth Street, 80 feet from Twenty-eighth to Thirty-fourth, and there should be one sidewalk—on the north side—only.

When it is realized that the whole of the city on the North Side from the Allegheny River to the Fort Wayne Railroad and from the Allegheny to Monument Hill was under water during the 1907 flood, it is not making an extravagant claim to say that the whole of that section of Allegheny between the Pennsylvania Railroad and the foot of Monument Hill and the proposed new wall would be reclaimed and would be rebuilt with modern structures.

Utilization of Reclaimed Area. Three uses of this most valuable acreage will be considered. The city owns and controls the present landings from Grant Street on the Monongahela River to Tenth Street on the Allegheny River and, with the co-operation of the United States government, can bring about a new condition that will enable this city to enjoy for all time (1) a wonderful boulevard, (2) a modern wharf, and (3) an improvement in transportation facilities.

It is proposed that in place of all the street-cars entering into the central business district of the city, and using the streets in that region, they be connected with six elevated tracks extending along the wharf from Tenth Street on the Allegheny River to the Point, and up the Monongahela River to Grant Street, where they would enter a subway under Grant Street extended to Liberty, and go thence to the intersection of Tenth Street and Duquesne Way, where they would come out to daylight again.

If this plan be carried out, it will mean that every street-car crossing the Monongahela River or the Allegheny River into the city, or crossing Grant Street and passing down Penn and Liberty Avenues into the city, will be taken off the surface. All street-car rails in the process of time would be removed from the surface of the street and all the poles and electric wires connected with the street-railway would be removed. Every street-car entering the city would pass around the elevated-subway loop and stop at every one of the eight stations. The morning passenger traffic from these eight cen-

trally located stations would pass towards the center of the city, passengers going from the nearest station to their respective points of business, and in the rush hours of the evening this same traffic would radiate like the spokes of a wheel out from the center of the city following the lines of least resistance, each individual knowing that every street-car would pass every station. It is planned that every station should have a modern waiting-room in each of the eight different central stations. The gallery leading to the six tracks and the stairs from the gallery to the platforms would all be under cover. That feature, to a city located as Pittsburgh is, when the weather is so frequently inclement, is a condition of convenience that has never been enjoyed. The proposed stations are planned to be long enough for six cars. The surface street-cars for each track would connect with and leave their respective elevated tracks at the same point.

No attempt will be made at this time to describe the despatching of the cars over the six tracks of the elevated-subway belt line. Suffice it to say that they can be run as trains, and colored lights on each platform can be used to identify the respective positions of the different car lines. For instance, take the Negley Avenue line (No. 71), which is indicated, in the plan now drawn, for track No. 3. It would make no difference in what part of the city a passenger might be, he would go to the nearest station, go to track No. 3 and then look to see where car No. 71 was to be placed on the platform for track No. 3. It would be a very simple matter to go to the right spot and step into the car. Furthermore, it would make no difference what part of the city it is desired to reach, he could go into any one of the stations knowing that every car in the city on every line entering the city would pass through every station and be on one of the six tracks.

The time has come when additional surface should be provided on our sidewalks. It is believed that the city should proceed at once to make plans for the building of a subway sidewalk on Sixth Avenue extended, from Grant Street to Wood Street, and a subway sidewalk on Diamond Street extended, from Grant Street to the Market, and a moving sidewalk on Fifth Avenue from Grant Street to Wood Street, or possibly as far down as Market Street. To extend any one of the three farther would be going into flooded area; but whether any wharf walls are built, whether any wharf improvements are made, whether any elevated road or subway is constructed, the subway sidewalks should be built now.

Rapid Transit. The building of such a belt line can be so arranged that, if it is ever desired (and it will be desired) that the city have rapid transit, the two systems will not in the slightest interfere with each other, but can be and should be made to correlate one with the other.

Design of Elevated Tracks and Stations. The proposed design contemplates the construction of plate-girders supported on columns and incased in concrete over which is laid a reinforced concrete slab. Upon this slab can be placed ballast, ties and rails, laid in the usual way; or, preferably, longitudinal and cross timbers to which the street-car rails would be bolted. This style of construction has been in operation for years in Philadelphia, and even with a slab wide enough for two tracks the movement of elevated rapid-transit trains produces only a rumble that is not in the slightest objectionable. With a slab such as the present plans contemplate—supporting six tracks, and the street-cars on all six moving in the same direction—the noise would be almost negligible, and at most only a rhythmic rumble.

The columns supporting the girders and tracks would be about 40 feet apart, and the whole of the elevated steelwork incased in concrete would give a pleasing appearance. The stations would be long enough to accommodate six street-cars at once. The main stairway leading direct from the sidewalk to the gallery, and the stairways leading to the six tracks, would all be under cover, and even the six platforms would be under roof and have solid concrete sides. Only the entrances and exits for the six tracks would be open. The design throughout is the simplest and cheapest to construct. With few exceptions the grouping of the street-car lines entering the city and their connections with the six tracks conform with the present method of routing. The proposed arrangement would be about as follows:

Routes	Cars	Trailers	Track
Smithfield Street	115	30	1
Second Avenue and Wylie Avenue	79	5	6
Forbes Street and Fifth Avenue	92	55	3
Liberty Avenue and Penn Avenue	48	38	5
North Side (170 cars)	130	39	4
West End and 40 cars from North Side	93	14	2
	557	171	

Design of Subway. The design of the subway under Grant Street contemplates a double deck of the usual subway construction which at Seventh Street widens out to six tracks and passes through and under the property of the Pennsylvania Railroad Company to the Allegheny wharf, six tracks abreast. This was done in order to place the six tracks just under the surface and minimize, as much as possible, any danger of flooding the subway. It is contemplated that station No. 8 at the Union Depot be incased and thereby insured against any possible trouble or delay from extreme high water; and that the same precaution be exercised at the subway entrance at the Baltimore & Ohio Railroad depot.

Pittsburgh's Wharves. The building of the river walls—or wharf wall, as it is so frequently called—should be contracted for and the work started before any subway work is started in this city. There is always confusion and congestion due to the building of a subway, but, provided the wharf is started in advance, the proposed subway along Grant Street can be so handled that the amount of confusion will be minimized; for the wharf would be used as a yard for the contractor on the elevated work, and a yard for the contractor on the subway, and the fill behind the wall should be made from the excavation in the subway which would have an entrance at Grant Street on the Monongahela wharf, and an entrance at Tenth Street and Duquesne Way on the Allegheny wharf. A yard such as the wharf would furnish, and a dump such as it would provide, would not only reduce the cost of the elevated construction, but would very greatly reduce the cost and time of construction of the subway under Grant Street. There has been considerable discussion of building a subway loop in the central business district of this city. If this should be attempted, the confusion therefrom will be intolerable and it will last for years, and when done would be only a partial relief of the congestion that will face this city next summer and constantly increase. Neither will the proposed subway loop be a solution for future rapid transit. The wharf and elevated-subway belt solve and make possible the following:

1. Street-car transportation in the central business district.
2. Street traffic.
3. Parking facilities.
4. Flood protection.

5. Avoidance of delays due to fires.
6. Avoidance of delays due to parades.
7. Double decking of Seventh Street bridge, with North Side cars on the upper deck; also a similar arrangement on the new Point bridge.
8. Bridge approaches.

Taking all the inbound street-cars and putting them onto a belt line is like building a great by-pass around the city, and it will not only by-pass the street-cars, but will furnish around the city an 80-foot boulevard which from Smithfield Street on the Monongahela River to Tenth Street on the Allegheny River will have grade crossings only at Sixth, Seventh and Ninth Streets, and these can be avoided by constructing passageways above or beneath.

It is believed that in the near future a semi-subway for trucks and heavy travel will be provided just back of the new walls, with exits and entrances where deemed best. This will provide parking space that will be owned and controlled by the city, and a future subway for parking under the driveways of the wharf that can be made to meet almost any limit. It will be above flood height; the ordinary fire in the city would not affect traffic on the elevated-subway loop; and parades, at best, could interfere with only one or two streets. It might, if it went out Fifth Avenue or came across from the North Side, cut out one track of the six. The building of the wharf simplifies the construction of the Point bridge, the Sixth Street, the Seventh Street, and the Ninth Street bridges, for they would land on a parkway.

The plans further contemplate the diverting of all the street-cars now coming across Sixth Street and Ninth Street from the North Side to either a surface or double deck on the Seventh Street bridge, leaving the Sixth, Seventh, and Ninth Street bridges for vehicular travel. It is believed that the wharf on the Monongahela River will never be used for any other river traffic than that now handled by river packets, and that the wall at this point should be constructed to meet these conditions. Heavy freight destined for railroad connections would naturally be received at points convenient to railroad terminals. Heavy freight destined for the city should be received along a wharf on the North Side below the Manchester bridge—a wharf which could be extended up the Allegheny River indefinitely. The

elevated tracks on the wharves, the driveways, the boulevards, the wharf walls, and the river terminals would be the property of the city. Pittsburgh has no improved highway directly through to the west. There is a highway to Wheeling by way of Washington, Pa., and there is a highway west by way of Darlington, but none directly west to East Liverpool or Steubenville. If there were, we would get our share of business from 500,000 people who now go to Cleveland. They want to trade here—but what about the parking facilities? It is hoped the State Highway Department at Harrisburg will join with the respective counties in building highways to East Liverpool and Steubenville. West Virginia has agreed to join in such a movement. The William Penn Highway, Perry Highway and other important highways should soon be completed, and when turned over to travel will bear the same relation to the merchants of Pittsburgh as those west. Pittsburgh must reclaim the acreage on the wharves, thereby meeting the demands of the present, and preparing for the future.

Navigation. Those claiming to represent the interests of navigation defeated the move made in 1911 by the Flood Commission to build a wall around Pittsburgh from Smithfield Street to Ninth Street. It is possible that the same interests will oppose the building of a wall to a new harbor line along the Monongahela and Allegheny Rivers at this time. There have been two arguments used in the past. The first was that the building of a wall would make it impossible to hold floating craft in the Monongahela or Allegheny Rivers during times of flood or ice. The second argument was that it would destroy the wharf, especially on the Monongahela River, and, consequently, the interests of navigation. The report of the Flood Commission recommended, among other things for this district, the dredging and removal of the Glass House riffle at the head of Brunot Island and the closing of the back channel by the building of a dike from the upper end of Brunot Island to the mainland. This plan, if carried out, would provide one of the best landlocked safe harbors in the whole upper part of the Ohio River, which would be big enough to hold the combined fleets of the upper Ohio River, and would be in the city limits.

The building of walls on each side of the river and the dredging out of the bed of the river to a uniform depth, as always has been contemplated, will provide a uniform flow the whole way across the river

and proper protection for navigation can be easily provided in the immediate vicinity. Regarding the claim that the walls would be an encroachment, it is interesting to note that, on the Allegheny and Monongahela Rivers just above the proposed walls, the United States government has approved harbor lines that are 100 feet narrower than the narrowest point that the proposed walls would establish and that at the mouth of each river the width will be from harbor line to harbor line and not on a sloping bank. There will be a vertical wall which will provide freer discharge of flood water than can now take place and will actually reduce the maximum flood height.

As regards the merits of the two arguments, you have the results of local navigation down to date. It is almost a back number, and to-day packet boats are tied up on the Monongahela wharf representing bankrupt concerns—concerns that have been already levied upon. If there ever is extensive navigation in our local rivers—and handling of heavy freight to and from Pittsburgh other than that shipped by private enterprises at freight terminals, which represents the bulk of business to-day—it will not be from the Monongahela wharf, and not be along the proposed wall, but at terminals where the railroads have their yards. The natural location for a terminal for freight destined for the business of the city proper would naturally be on the North Side near the Point on the Allegheny River. The only important business that would desire a landing along the Monongahela or Allegheny wharves in the central business district of the city would be high-priced freight and merchandise, which, if the wall were ever built, could be handled from warehouses on the river front. The same problem is completely solved at Düsseldorf and other cities on the Rhine.

Navigation will be made by Pittsburgh. Pittsburgh is not holding her own with other cities. When compared with the growth of our greatest competitors, we are slipping backwards. Everything possible must be done to further Pittsburgh's supremacy. Pittsburgh's supremacy will insure navigation on the Ohio River, but navigation on the Ohio River will not insure Pittsburgh's supremacy.

Floods. The exhaustive study and report of the Flood Commission, published in 1911, revealed the facts that the direct loss in Pittsburgh and immediate vicinity during the flood of March, 1907, was over $6,000,000; that including the indirect loss it was $12,000,000;

and that the average annual loss is $2,000,000. This loss was brought about by two different causes—flood waters on the low-lying streets, and back-water from the sewers. Since the disastrous flood of 1907 the city has spent several millions of dollars in raising streets in the central business district and on the North Side to the level of practically all of the floods that we have ever had except that of 1907. Building the wall to that height and not controlling the back-water in the sewers would be only partially meeting the flood conditions. It would meet them in so far as travel on the boulevard is concerned and it would meet them in so far as travel to and from the bridges is concerned.

Practically all of the large buildings have arranged to take care of back-water through the sewers, but a multitude of small concerns have not made any provision of this kind, neither could they afford to do so. In the building of the walls along the river front there should be a large sewer built back of each wall, connecting with all of the sewers now emptying into the rivers from the central business district and emptying into a large sump at the Point, with provision for pumping sewage therefrom during all floods. Pumps necessary to control the sewage would be buried underground and completely out of sight at the Point. In certain sections of the city there would be some trouble from seepage, entirely independent of raised streets and sewage; but, with the walls built, the streets raised, and the tracks elevated, our great flood problem would be solved.

The City Beautiful. The appearance of the wharves of our city to anyone coming up the Ohio River on the Pittsburgh & Lake Erie Railroad or in by way of the "Panhandle" or by the Fort Wayne Railroad is a disgrace. The building of the walls as proposed along our river fronts would add to the appearance of the city. The elevated structure as contemplated would consist of cross girders every 40 feet, supported on columns with curve brackets at the top with longitudinal plate-girders supporting the six tracks, which would rest on a reinforced concrete slab the full width of the six tracks, and all be incased in concrete. The elevated structure can be made beautiful to look at and that with a very moderate cost; in fact, taken over a period of years, it would be cheaper to incase it in concrete than it would be to keep it painted and cleaned, and there is no comparison as regards appearance.

Pittsburgh's Problem. The problems of transportation, floods, congestion, etc., are so peculiar to Pittsburgh that the successful solution in other cities will not necessarily solve ours. Local engineers, all members of this Society, solved the flood problems in such a masterful manner that the above-mentioned report published in 1911 is looked upon as an authority in every country of the civilized world. We have, right in the city of Pittsburgh, the offices of the two largest bridge-building companies in the world, and Pittsburgh has engineers eminently capable of designing the elevated tracks on the wharves, and the subway under Grant Street. The local engineers are thoroughly acquainted with the local problems and need no outside advice. They have been successful engineers and can draw plans for the proposed elevated-subway system that when built would be a model of perfection. We have in Pittsburgh the best contractors for such class of construction in the United States. We will furnish all the material and fabricate it at home. Why go outside of Pittsburgh? Why delay action? Why ignore the engineers of Pittsburgh who have made world-wide names for themselves?

Relation of the Pittsburgh Railways Company and the Pennsylvania Railroad to the City of Pittsburgh. The Pittsburgh Railways Company has in the past opposed any move for rapid transit. The receivers gave the best service ever provided and brought the maintenance and equipment forward even during and after war times. Their administration has been splendid. It is hoped that the new 10-year contract will witness a condition of transit in all respects at least as good. The tonnage in the Pittsburgh district is as great as in any other two cities in the United States. It is equal to that of New York and Chicago combined. Yet when the improvements in Pittsburgh made by the Pennsylvania Railroad are compared with those of New York, they are meager. If the Pennsylvania Railroad will now join the city of Pittsburgh on an equal give-and-take basis both will be the gainers. Both need help, for both may slip back. Now is the psychological moment for the United States government, Pittsburgh, the Pittsburgh Railways Company and the Pennsylvania Railroad to pull together.

Fig. 1 shows a plan made by the Flood Commission of Pittsburgh. The shading represents the flooded district in down-town Pittsburgh and on the North Side during the flood of March 15, 1907.

Fig. 2 represents the proposed wharf walls along the Allegheny and Monongahela Rivers, and the location of the elevated-subway street-car lines on the wharf and under Grant Street. Eight stations are shown in shaded blocks—four elevated stations on the wharf; one half elevated, half subway, at the Baltimore & Ohio Station; and three subway stations under Grant Street.

Fig. 3 is a typical section of the present, and proposed, wharf at any one of the four elevated stations and a general cross-section of the station showing the arrangement of the gallery, stairs, and six elevated tracks.

Fig. 4 shows the arrangement of the combined subway and elevated station at the Baltimore & Ohio Station.

Fig. 5 is a typical section of the subway stations on Grant Street between Diamond Street and Fourth Avenue, and between Oliver Avenue and Sixth Avenue.

Fig. 6 is a side elevation of the station at the Union Station.

Fig. 7 shows the proposed arrangement of the elevated tracks, the new Point bridge, the Manchester bridge and the Duquesne driveway and boulevard at the Point.

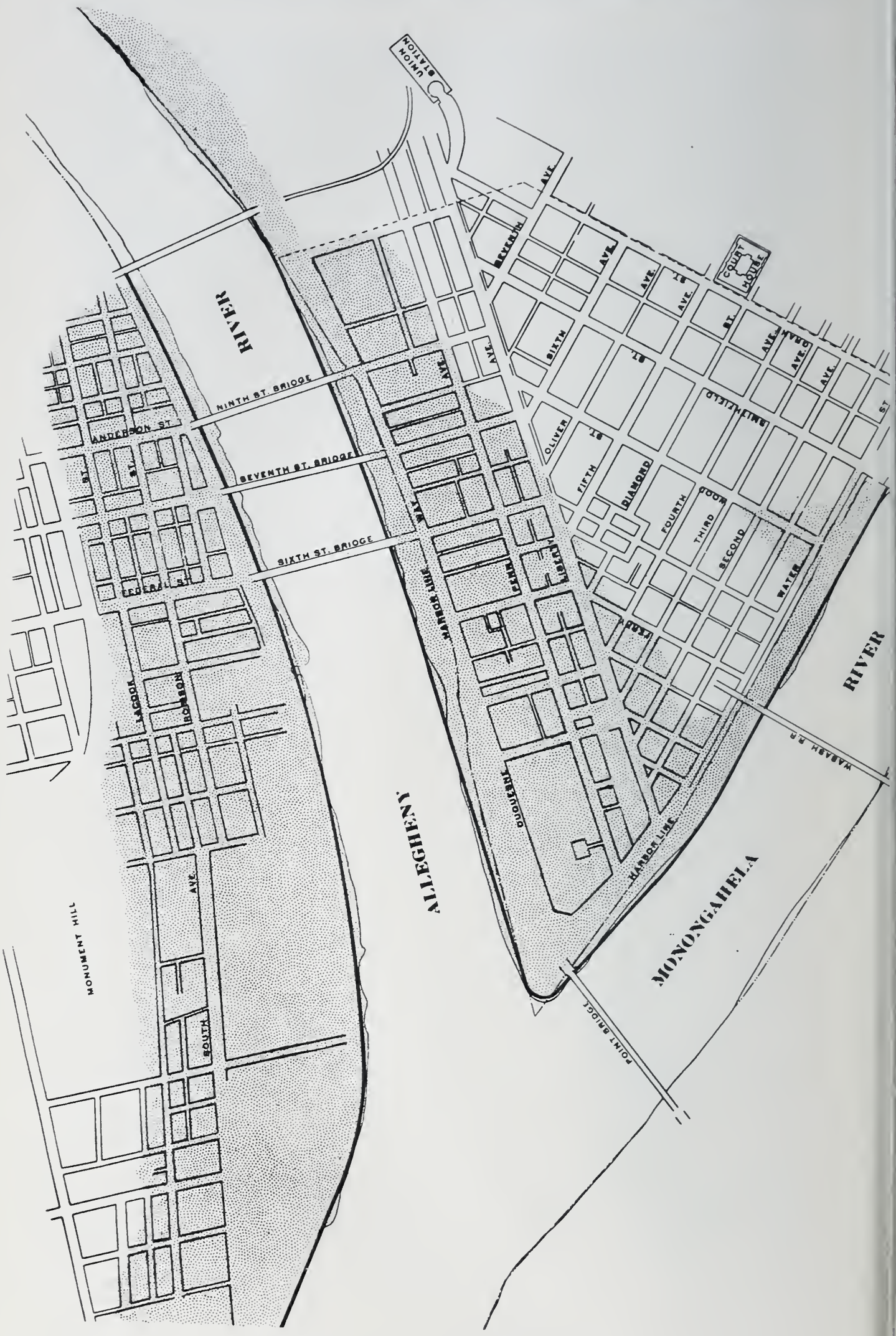

Fig. 1. Area Flooded in 1907.

Fig. 2. Proposed Wharf Walls and Street-Car Lines.

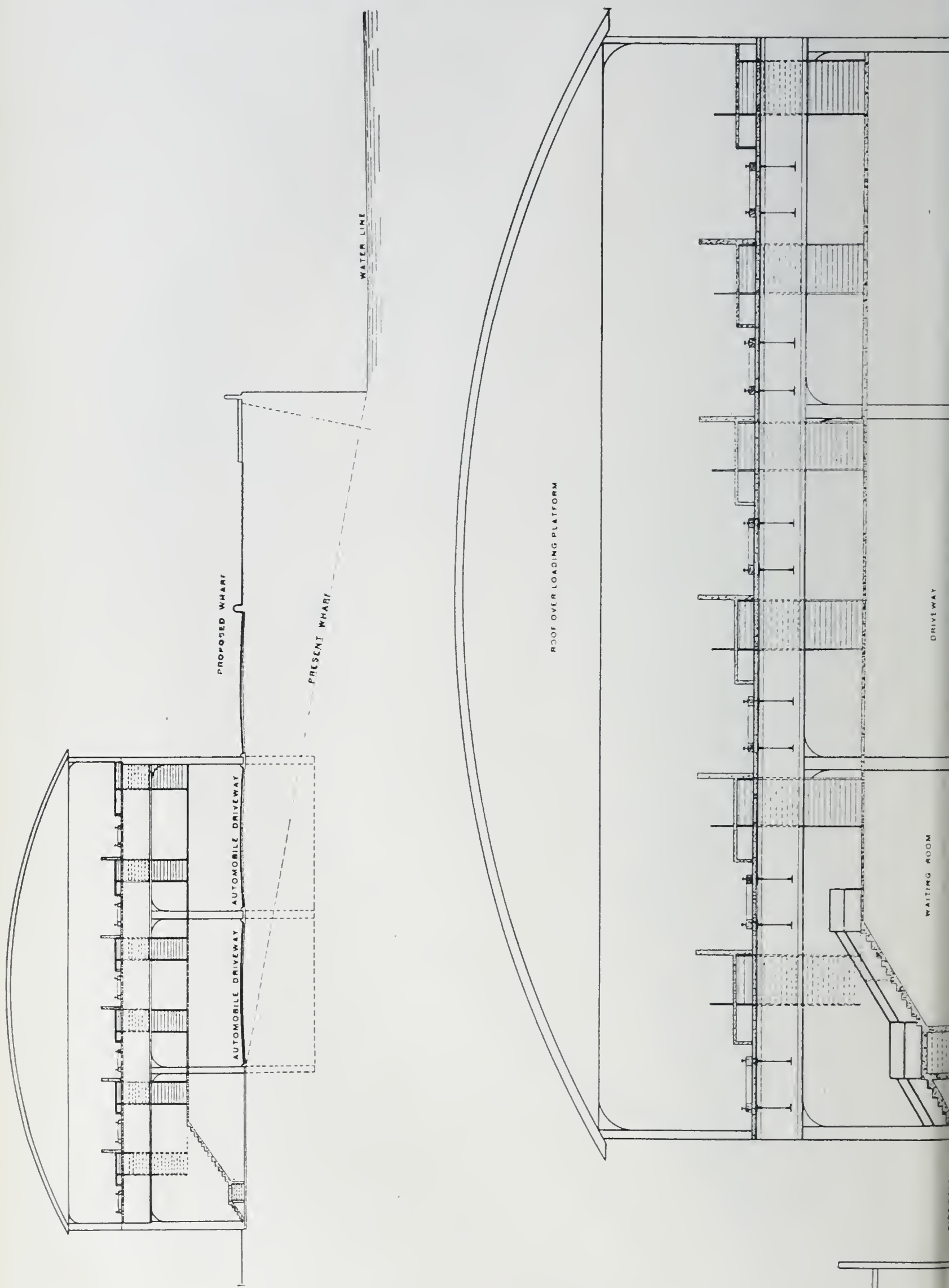

Fig. 3. Cross-Sections of Wharf and Station.

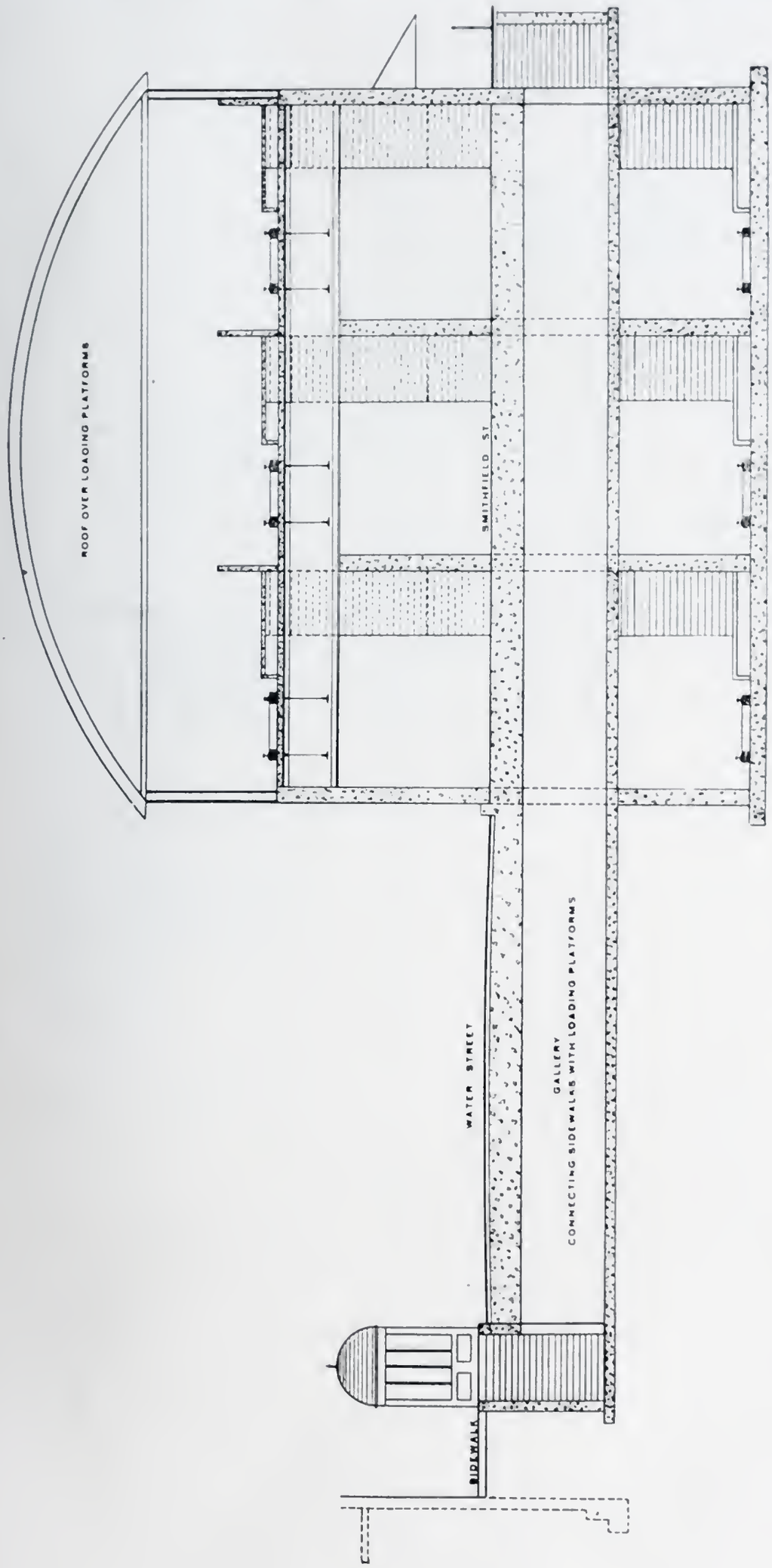

Fig. 4. Combined Subway and Elevated Station.

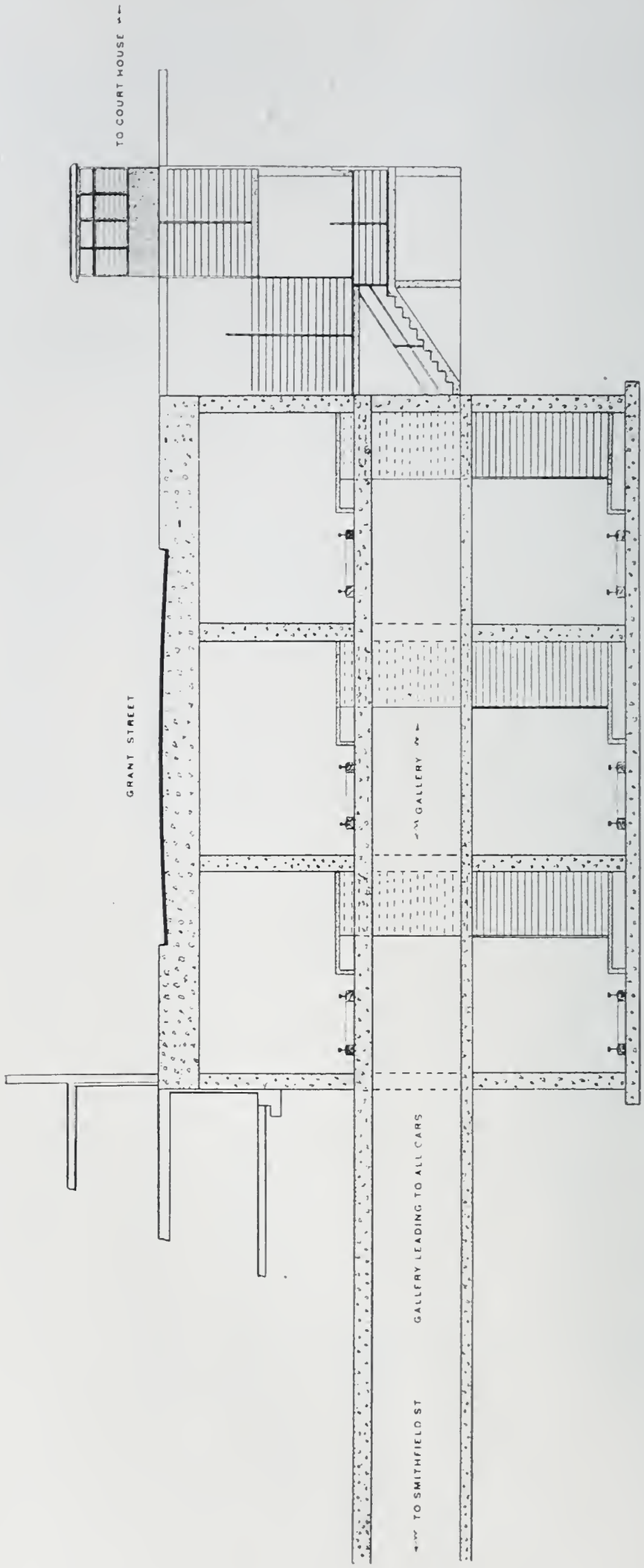

Fig. 5. Cross-Section of Subway Stations.

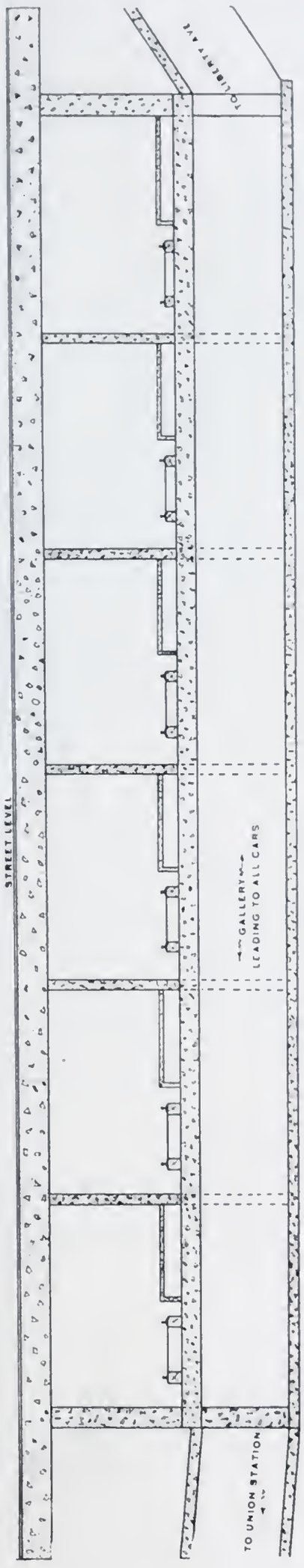

Fig. 6. Subway Arrangement at Union Station.

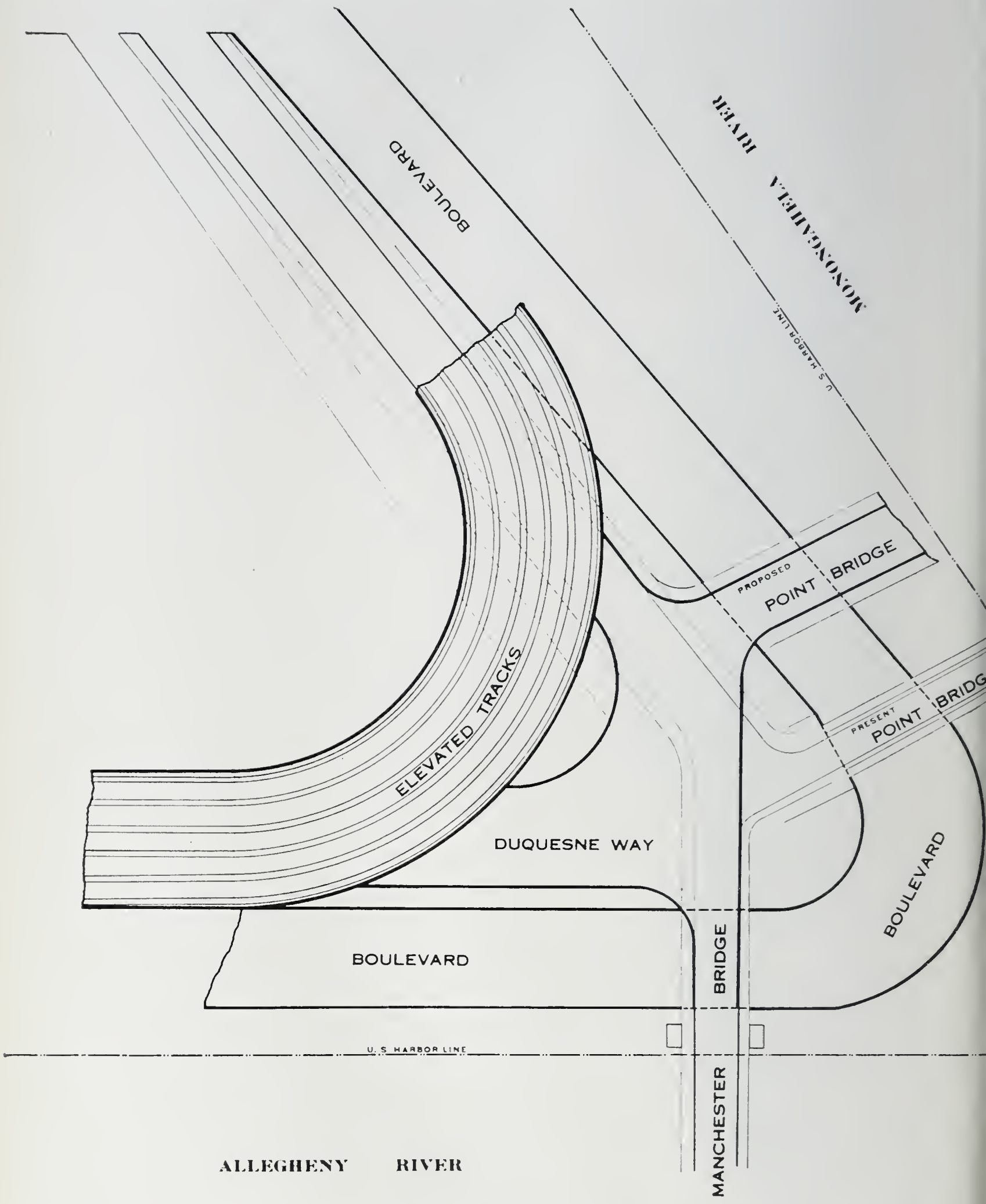

Fig. 7. Proposed Arrangement at the Point.

DISCUSSION

Mr. Frederick Crabtree, *Chairman*:* No one who has not given considerable thought to it could add very much or comment very wisely on such a tremendous proposition; but there are many here who have also studied this problem who are undoubtedly capable of commenting as Mr. Morse would probably desire. I am sure Mr. Morse would welcome any questions or comments on the paper.

Mr. Richard Hirsch:† I would like to ask if this takes into consideration the plans of the Pennsylvania State Board of Health on the subject of sewage disposal. The day is surely coming when the State Board of Health will not permit sewage of the large cities to be emptied into the rivers and some solution of that problem will have to be found sooner or later. You say there will be a sewer system back of the wharf retaining walls. Could that sewer be designed so as to form a part of a general sewage disposal system, which will some day have to be built under the requirements of the state of Pennsylvania?

Mr. E. K. Morse: That has been considered. It is believed that the only way you can take sewage from down town is to take it to that point, and then pump it to some convenient point where it could be treated. But the city of Pittsburgh is confronted to-day with the question of the $30,000,000 needed to handle our sewage. It is so large a problem that the authorities at Harrisburg have been a little timid about pressing it upon us.

Mr. Frederick Crabtree, *Chairman*: We have with us Mr. Burchfield, a public-spirited citizen who has devoted a great deal of time and money and effort to the study of this problem. We would be glad to hear from him.

Mr. A. H. Burchfield:‡ I do not know that I have anything to add to the statements made by such an eminent engineer as Mr.

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†Mechanical Engineer, H. K. Porter Co., Pittsburgh.
‡Joseph Horne Co., Pittsburgh.

Morse. I feel he has presented the subject in a way that anyone can understand; also, I presume that you do understand it because you have asked no questions. Having been associated with Mr. Morse on many commissions—flood, transit and others—I know that he is the engineer best qualified to talk on these city problems.

He has provided a way on the wharves from Eleventh Street to the Point, and up Water Street to Smithfield Street, for the parking of some 25,000 automobiles during a day, and when you have done that I think you have solved the parking question for to-day, tomorrow and next week.

Perhaps the most intricate thing to understand is the loop with its deposit of passengers at stations. It deserves careful thought and study. I believe that when you study it, you will see that removing the street-cars from the surface is advantageous and will permit them to give better service. The automobilist feels that if the street-cars were off the city streets in the down-town region it would afford him better driving conditions. The pedestrian feels that he should be able to cross the streets in safety.

Mr. Morse touched on one thing which I believe deserves considerable thought, and that is that the people of Pittsburgh voted for a subway in the First and Second Wards at the cost of $6,000,000. According to its advocates, it was to consist of two tracks, supposedly to come down Sixth Avenue, along Liberty Street, and up Diamond Street. If two tracks would accommodate without any delay 550 cars in an hour, this would be satisfactory; and if it did not cause congestion at the entrance to and exit from the subway, that would be fine. If I ask the men in this room to crowd into the center of the room there would be congestion, and if I ask you to go to the edges of the room it will not be so crowded in the center.

One has considerable trouble to-day if he wishes to attend the theater. For instance, a man living in the West End leaves his car at Stanwix Street and Liberty Avenue, and if he is going to the Nixon Theater he has some walk on the surface of the streets. However, if he wished to go to this same theater and we had the proposed loop, he could remain on the car and alight at the station nearest to this theater, all of the theaters being very close to the rim. In fact, he can attend any theater, no matter where he lives, without much inconvenience, and can also change his residence two or three times a year

by taking another street-car and remaining on it until it reaches the station nearest the theater which he wishes to attend. If one visualizes the locations of the theaters with regard to the stations on this loop, he will see that the distances are very moderate.

Nearly every man in this room visits the City-County Building during the year. He can leave his car at the station opposite the City-County Building, the Frick Building, or the Union Arcade, and this loop puts him within two squares of most of the large office buildings. If he wishes to go to any of the hotels, he will find that the stations on this loop are within one or two squares of the hotels. If every man in this room, when we dismissed, returned to his home by street-car, he would have to walk only from the William Penn Hotel and enter the subway station—at Grant Street and Sixth Avenue, or Grant Street and Oliver Avenue, half a square away—on one of the six platforms and take his car to his home, no matter where he lived.

An adequate transfer system could be inaugurated for a continuous ride from the point farthest north to the point farthest south by transferring at any station on the loop. For example, if you live in Crafton and wish to go to Carnegie Library of Pittsburgh, Carnegie Music Hall, Homestead, or the East End, you would transfer at any station on this loop, from one track to another, and continue your ride. To do so to-day you would be put to the inconvenience of much walking on the surface of the streets. By this new system, you would not have crossed the street or entered any of the city streets and would have done your transferring under cover at any station.

After seeing the pictures of our present wharves and the pictures of foreign wharves, shown some three months ago at Carnegie Lecture Hall, one cannot help but feel that ours are a disgrace, and the suggestion of the wharf wall to confine the waters of the Allegheny and Monongahela Rivers should be adopted and the floods stopped; also, the addition of fifty to sixty acres to our down-town triangle should be urged.

Mr. E. K. Morse: The plans contemplate closing Liberty Avenue from Eleventh to Thirtieth, and all the cross streets to Penn Avenue; widening Penn Avenue to 120 feet from Eleventh to Sixteenth, to 100 feet from Sixteenth to Twenty-eighth, and to 80 feet from Twenty-ninth to Thirty-fourth.

Mr. T. M. Rees:* I have in years past navigated on the Allegheny, Ohio and Monongahela Rivers, and have been, and am, part owner of about 51,000 square feet of property in the section that Mr. Morse speaks of as being so valuable.

In 1914, the grade was changed on Duquesne Way and the lower part of Fancourt Street (old Fourth Street), which before changed was practically the same as at Liberty Avenue. Since the change, the grade is four feet higher than at Liberty Avenue and, in consequence, there would be four feet of water at the latter point before it would come on Duquesne Way and the lower end of Fancourt Street. This changing of grade destroyed our property for the business we were engaged in, though we have been located there since 1854.

Our taxes are three times what they were in 1913, and, while it is true we have not been affected by floods over 28 feet since 1913, I firmly believe the height of the water has been greatly reduced by the sand boats digging away the bars; as, for instance, where the bar at the mouth of the Allegheny would be out of the water at three-foot stage, there are now 20 to 30 feet of water. I consider that the sand boats have done, and will do, more good by digging and lowering the bed of the river (which will largely reduce the flood stage) than anything the Flood Commission has yet offered. I favor all that the Commission desires to accomplish by the use of reservoirs and storage of water for prevention of floods for the benefit of navigation, as I believe the time is coming to make use of water for power purposes as is done on some of the rivers in this country.

At one of the bridge hearings held in Pittsburgh in 1901, I made the prediction that we would some time have 40 feet of water. The prediction was based entirely on conditions that then existed regarding encroachments on our river banks; this together with a sudden rainfall, freshet, or breaking of ice in the early spring. It is entirely due to encroachments made on our wharves that we have suffered so much from floods in the past.

I recollect very distinctly that in the year 1852, when I was a boy, by taking the building line on Water Street and on Duquesne Way at the point of intersection of the Monongahela and Allegheny Rivers at a six-foot stage of water you could not get around from one wharf to the other without getting into water if you followed the

*General Manager, James Rees and Sons Co., Pittsburgh.

street line of Duquesne Way; therefore you can see what encroachment has been made on our wharves.

I have seen people walk across the Allegheny River at the Point at a three-foot stage of water in the river, putting planks across from what was known as Pucketa Chute to the bar on the Pittsburgh side, and planks across from what was known as Duck Chute on the Allegheny side, the remainder of the bar being comparatively dry. At a six-foot stage of water the bar would be covered to South Avenue at Grant Avenue on the Allegheny side, and where at one time there were about 2400 feet between river banks there are now about 1020 feet. The latest measurements I have of distance between the Point bridge abutments, or that of the old Union Bridge in 1870, the line was about 190 feet from the building line on Duquesne Way, while at the present time it is 260 feet.

In years past, a comparison of the height of water at Franklin and Oil City on the Allegheny River, and on the Monongahela River at Brownsville, shows that there has been an increased height of about five feet of water in the harbor at Pittsburgh, due largely to the encroachments that have been made on the banks and wharves of the rivers in the vicinity of Pittsburgh, curtailing its width, which also increases the velocity of current in the river. It is quite easy to say you can hold steamboats and other craft outside of the wall, but it is another thing to do it. I owned stock in a wharf boat, formerly used by the Pittsburgh and Cincinnati Packet Company, which was sunk and carried away at our Monongahela River inclined wharf. With our inclined wharf, when the river rises it allows the boats to follow up the rising water and gives better protection from current in the river, but with a perpendicular wall the river craft would be compelled to stand out in the dangerous current unprotected from ice or any floating object that might break loose above the wharves, and it would be impossible to say where you could moor water craft in safety.

The ice in 1904 caused a loss of $75,000 to $100,000 to the Monongahela River Consolidated Coal and Coke Company, in what was considered the only safe harbor in the city of Pittsburgh, and experienced men on the river do not hesitate to say it would be impossible to hold river craft in safety with your proposed high wall around the public wharves, as time and again I have seen barges and

steamboats sunk at our wharves due to sudden freshets in the spring.

The records in years past will show that the city endeavored to have a bill passed in 1893, known as the Flinn Senate Bill 34 and 35, which was to change, alter, beautify and improve the wharves. Although the bill was passed by both the Senate and the House, it was vetoed in June 1891 by Governor Pattison. In 1891 an attempt was also made by Mr. Bigelow, chief of the Department of Public Works, to beautify the wharf by making a park of it, but when the matter was taken into court he was given two weeks to remove all the filling he had placed on the wharf and to restore it to the condition it was in before he attempted to alter, or be held for contempt of court. Other attempts have been made to get possession of the city wharves, but they have failed.

The grant or donation of the public wharves to the city of Pittsburgh forever I think will hold. It is true, and very unfortunate for the city of Pittsburgh, that the United States government has been very lax in protecting its rivers, but it has passed the River and Harbor Act within the past twenty-five years. This act also assists in protecting grants similar to the grant made to the city of Pittsburgh for its public wharf free and forever. I here submit a section of the above-mentioned River and Harbor Act of March 3, 1899:

"Sec. 10. That the creation of any obstruction not affirmatively authorized by Congress, to the navigable capacity of any of the waters of the United States is hereby prohibited; and it shall not be lawful to build or commence the building of any wharf, pier, dolphin, boom, weir, breakwater, bulkhead, jetty or other structures in any port, roadstead, haven, harbor, canal, navigable river, or other water of the United States, outside established harbor lines, or where no harbor lines have been established, except on plans recommended by the Chief of Engineers and authorized by the Secretary of War; and it shall not be lawful to excavate or fill, or in any manner to alter or modify the course, location, condition, or capacity of any port, roadstead, haven, harbor, canal, lake, harbor of refuge, or enclosure within the limits of any breakwater, or of the channel of any navigable water of the United States, unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of War prior to beginning the same."

The plan that Mr. Morse has developed is exactly what Mr. Bigelow sought to accomplish by Senate Bill No. 34. In the fall of 1914 Mr. Robert Swan came into our office and found my attorney and myself with the papers of a suit entered against the city of Pitts-

burgh in 1891. My attorney was to enter proceedings against the city to compel restoration of the wharf in a manner similar to what was accomplished by suit entered in 1891. Mr. Swan promised, if I would not bring suit, to pave Fancourt Street to the water line and put it in condition so we would not have any trouble delivering our machinery by wagon to boats lying at the wharf in front of our works, and I agreed to withhold bringing suit, but before he had sent the papers in regard to his proposition he took sick and died. Owing to the washing down of deposit from above on the wharf, it is in a dangerous condition for teaming to the water's edge. Our letters on this subject written in July 1914, July 28, 1915, October 28, 1915, and April 1917, to the chief of the Department of Public Works fully verify this statement.

In April 1920 the Pittsburgh Railways Company was again permitted to change the grade in front of our works, this time lowering it below the old grade of Duquesne Way to permit the "Butler Short Line" cars to pass under the Pennsylvania Railroad bridge across Duquesne way, placing a hand-rail on the sidewalk to prevent pedestrians from falling off into the street. This made considerable change or variation of grade into our works—in fact, fully 10 per cent. grade at one point—which virtually ruined the boiler and shipyard department for the work it was built for, as owing to this grade fully 20 to 30 per cent. was added to our labor bill and we were compelled to abandon the class of work we have been doing on our city wharf for oyer fifty years and see our competitors securing it at locations from the head of the Ohio River to its mouth.

Attention has been called to the Seine where the city of Paris had its high wall at the time they were advocating issuing bonds to build the high wall around our wharves. The city of Paris was then building docks out into the river, and also roadways from its bridges which crossed the Seine down to these docks at a grade of five per cent., in order to get the benefit of river transportation to these points in the city from other ports on that river. The engineers sent over by the city failed to take notice of this, although the small passenger boats landed at these docks within thirty to forty feet of the docks that were built and being built. I was in Paris at the time the Pittsburgh engineers were there and saw them sometimes three and four times a day, as I was held there over six weeks awaiting develop-

ments and spent some time every day on the river and examining the grades on river and bridge approaches. I will give you some data from a report of a commission that was appointed by the city of Paris to investigate and report on the causes and remedy to relieve the situation. A translation which I have among my files reads thus:

"Undoubtedly the encroachments on the banks by the wharves and the obstruction of the bed of the river by the piers of the bridges are a nuisance. From this it is evident there was abuse, and it is occasionally acknowledged. They are trying to relieve the conditions, for example: By widening the bridge of 'Notre Dame' and doing away with two of its four piers; they are also constructing a very large sewer, known as 'Quai de Billy,' to follow the river, and take care of part of the water and drainage from one point to a lower point below the city, to relieve the situation. They are also agitating the dredging of the river and dredging of a canal through a neck of land above the city, to connect with the river below the city, to relieve the danger of a re-occurrence of the disastrous floods during the past few years."

I believe the cost of building the wharf walls, and the changes contemplated, would be a very large sum of money. Based on Mr. Morse's previous estimate that I heard in 1912, it would, I think, come near to, if not exceed, $100,000,000 before completion, as the changes to be made now are very much greater and costlier. The Sixth, Seventh and Ninth Street bridges are to be raised.

In 1874 we wrote the Secretary of War, Mr. Belknap, I believe, requesting that some action be taken regarding the Union bridge, which we tried to have raised twelve or fifteen feet to eliminate its very obstructive feature of being too low to have the ordinary passenger boat enter the Allegheny River, and Colonel Merrill made the report, which was the base or starting point. His report was that all the bridges across the Allegheny River which obstructed navigation should be removed to permit the safe navigation of that river, and at one of the early bridge hearings by the United States engineers I submitted a proposition by Mr. Glafey, a very competent engineer, made to him by the John Eichleay, Jr., Company to raise the Sixth Street bridge for $60,000. This price did not include the approaches.

I was present with Mr. Boggs, of Boggs & Buhl, on a steamboat with a committee from the Chamber of Commerce, and when told about Mr. Eichleay's estimate some years previously not being over $75,000, Mr. Boggs asked Mr. Gerber, the assistant to the president of the American Bridge Company, who was one of the committee, if

the Sixth Street bridge could be raised for $100,000, and Mr. Gerber answered: "Give me the $100,000, the permit, and the order to raise, and the bridge will go up, with all approaches made at the north and south ends of the bridge."

I wrote several letters to the Allegheny County Commissioners regarding the testimony taken and the condemnation of the low bridges across the Allegheny River by the United States Board of Engineers, and on March 11, 1911, when the papers gave out the report that they were arranging to buy the bridges, I called their attention to the fact that the navigation interests would not let the subject of the removal of the obstructive features lie dormant. Had the Commissioners looked into the matter more closely at that time, a large amount of money which is being spent to raise the bridges now would have been saved, as the matter of the vessels that could navigate on our rivers successfully, submitted on behalf of the bridge owners, was entirely wrong. It is true that for some years past we have not had the proper steamboats to handle the freight and passenger trade to and from the lower ports, simply because those previously engaged in the trade lost every dollar they had invested because of the experience in trying to navigate while the government was improving the rivers by building dams to permit uninterrupted navigation. This was started some fifty years ago in the building of Davis Island Dam, and the river dams are not completed to permit proper steam vessels for the trade to navigate uninterruptedly to Cincinnati at the present time.

If the former steamboats of the Pittsburgh and Cincinnati Packet Company were in existence in the trade between Pittsburgh and Cincinnati at the present rates for freight and passengers they would make good money for their owners under present conditions, and would be of great benefit to the citizens of Pittsburgh and vicinity.

I have a distinct recollection of the *Keystone State* bringing into the city on one trip 9000 cases of eggs containing 270,000 dozen or 3,240,000 individual eggs, and I have known the market price of eggs (about 1890) to be 40 cents a dozen on Saturday, and only 20 cents on Wednesday, due to river shipment by boats. With the improved rivers and the boats that will come with the improved rivers, you will see some very great improvement regarding prices of food supplies.

A modern side-wheel steel-hull steamboat has very recently been built, and I am in hopes that during the month of April the citizens of Pittsburgh will be able to see what character of boats may come to our city wharf with the improved rivers, thus doing away with the makeshifts that conditions compelled using. At the present time this fine new steamboat I speak of cannot navigate the Ohio River to its mouth except at high stage of water, owing to the tardy manner the government has pursued in improving the rivers. It is estimated at the present time that river improvements will not be completed before 1930.

In years past those who were mainly obstructing the improvement of the Allegheny River were loud in proclaiming that there was no good coal up the Allegheny River and there would never be a barge of coal come out of that river. If some of the gentlemen here will walk down to the La Belle Landing at the foot of Penn Avenue they will see four steamboats engaged in the trade of towing coal from the Consumers Mining Company at Harmarville, Pa., which is 12 miles up the Allegheny River, to the Pittsburgh wharf, and only one of the four can pass under the low bridges at a nine-foot stage of water in the river. They are taking from the mine an average of 2500 tons of coal every day when the water will permit boats to pass under the bridges.

It was from the English shipbuilders that our American boat-builders first procured the plans of the tunnel boats which have proven so disastrous on the Yukon River and on the Pacific Coast, the Monongahela, the Ohio, the Missouri, and certain southern rivers where I recently saw one sunk, this style of boat having been abandoned for river service in competition with the stern-wheel boat. This was the style of boat that Mr. Morse advocated in his article on the subject of steamboats published in the *Pittsburgh Gazette Times* of March 7, 1910. While it is true that a towing vessel with a wheel at the stern was patented in England about 1736 and may be called "antiquated," yet the tunnel-wheel propeller was patented in England about 1856, but the stern-wheel boat is still in use.

The best results by United States towboats built for service on the Mississippi River have been obtained from the designs and improvements made on this "antiquated" style of vessel by two Pittsburgh naval architects who were in the employ of our firm for years,

and time has shown that the government erred in the adoption of the tunnel type of boat, which has been found unsatisfactory for the service required.

I firmly believe that instead of trying to put obstacles in the way of the navigation interests, they should be given protection until river improvements are completed. No business can be successful with such obstacles as have existed for the past fifty years on our rivers. I am opposed to the proposed walls on our rivers for the reason that they will not be safe for mooring river craft, while the walls entirely destroy the wharves as dedicated originally to the public use by the Penns. They were assured to the public after protracted litigation mainly relating to the Monongahela wharf, in the cases establishing the public rights, "Commonwealth vs. McDonald, 16 Sergeant & Rawle (Pennsylvania), 390," and "Barclay vs. Howell, 31 United States Reports, 498." The same doctrine applying to the Allegheny wharf in "Schenley vs. Pittsburgh, 104 Pennsylvania State Reports, 472," and as to the Allegheny wharf the public had this further assurance by the Pennsylvania Act of March 31, 1836. Duquesne Way was established with a width of 50 feet, and the ground extending from Duquesne Way and the Allegheny River was declared to be set apart for the sole purpose of a public wharf and landing forever. Also, the act of April 6, 1867, consolidating the present city of Pittsburgh, does not give any power to sell or mortgage or lease any public squares or river shore landings, but they are to be held for public use as before mentioned.

Mr. Winters Haydock:* I think the remarks just made are leading toward a controversial turn of the discussion, but, nevertheless, I think that those who have misgivings as to the effect of the wharf improvements outlined by Mr. Morse upon flood stages should be reminded that this effect is susceptible of very close calculation by engineers in accordance with well-developed and thoroughly tested hydraulic formulæ. The effect upon flood stages was unquestionably figured out by the Flood Commission of Pittsburgh before it made its recommendations. I do not have any misgivings as to any serious consequences from the changes in the river cross-section which are proposed.

*Chief Engineer, Citizens' Committee on City Plan of Pittsburgh, Pittsburgh.

As to the objection which has been made to a change in the utilization of the wharf, I think we may get some light on that question if we consider the use at present being made of the wharf on the two sides of the triangle. On the Monongahela side we see the sloping bank being used by the old-fashioned packet-boats, as it has been used ever since the beginning of river navigation. On the Allegheny side we see an entirely different use being made of the wharf at present. At some points we see bulk material, coal, sand, and gravel, being hauled up the wharf in wagons and trucks from floating derrick boats, and elsewhere we see it being lifted vertically by cranes and put directly into trucks on a level with the street systems of the city. Of these two methods here to be seen side by side, I think there can be no question in the mind of any engineer as to which is the better. It would be ridiculous, if it were not so pitiful, to see these trucks going down the steep bank with their brakes set and being hauled back by a cable, when near-by we see the efficient plant recently installed near the Point for elevating sand and gravel to hoppers above the level of the streets, whence the material is drawn directly into trucks. The proposal of Mr. Morse, the Flood Commission of Pittsburgh and others who are recommending the development of the wharf along the lines Mr. Morse has discussed to-night would simply extend the method of handling bulk material now used at this new plant near the Point to the entire length of the Allegheny wharf. I do not see how there can be any objection to this improvement on the part of those who are handling bulk materials by the old method.

When it comes to the Monongahela wharf, we might take a different view of the matter. A sloping wharf probably best suits the requirements of the present packet-boat. My own thought is that perhaps we might postpone for the time being—at least as long as the old-fashioned packet-boat is still on the river—the vertical wall along the Monongahela wharf. If the packet-boat is succeeded by a more efficient type—such as is being used by the federal government on the Mississippi-Warrior River service—then we might complete the development of the vertical-wall system.

The indefinite postponement of the building of the quay-wall along the Monongahela River front need not interfere with the widening of Water Street to a proper width, as that can be accom-

plished by the building of a small retaining wall near the top of the slope, with short ramps placed parallel to it where necessary for the access of vehicles to the wharf.

This is the thought I would like to leave—that both methods of handling freight by river may be accommodated by supplying upon the two sides of the triangle the two types of wharf which are suited respectively to the needs of each method.

Changing the subject, I would like to speak of a very interesting detail which Mr. Morse has mentioned only very briefly; that is, his suggestion that the Point bridge, when rebuilt, be moved up stream, giving an offset connection between the proposed roadway leading down to Duquesne Way and the bridge approach. I would be very glad to hear him explain a little further the reasons for that offset. As a traffic control measure it may have some interesting complications.

Mr. E. K. Morse: My thought in that connection was that if the Point bridge were made as wide as it should be; as the community grows and makes street improvements to the west as it should, crossing on the Point Bridge, the Lincoln Highway and the William Penn Highway will enter Pittsburgh together, and go out together over the Point bridge. Imagine all that traffic from the west coming in at the present Point location! It could not be handled to-day. Separate the points of intersection of heavy travel, and congestion will be prevented to the maximum. Hold that peak down. It is a simple matter then for the policeman to regulate traffic and keep it down, and it is not crossing at right angles. This scheme would provide two intersections several hundred feet apart.

Mr. J. P. Leaf:* I have been very much interested in the discussion of these river improvements all the different times I have heard it. I agree with Mr. Rees on the improvement of the river. If the government insisted on the sand companies taking everything they dig, boulders and all, they would improve it mightily. It is simply a matter of cross-section. The deepening of the river will lower the flood crest for all ordinary purposes, I think.

*City Engineer, Rochester, Pa.

Mr. Morse's plan is fine. There is no reason why the wharves could not be retained. The Seine has walls and banks on both sides of the river, and flood passages or channels for high water. There is no reason why Mr. Morse's plan could not be worked out with covered back channels, which would increase the cross-section of the river.

About your highways, it is undoubtedly true that Pittsburgh is losing prestige by not having facilities to take care of people that want to come to your city. From Rochester, 25 miles down the river, the people do not bring their machines to Pittsburgh at all because the traffic arrangements in Pittsburgh change as often as the styles in the *Ladies' Home Journal* and nobody can keep track of them. I can not understand, being a farmer living down the river trying to get these improvements all my life, why in the world Pittsburgh permits the greatest asset the city has to be walled off as the Allegheny River is. Many cities are spending all kinds of money to open up traffic to their city; Pittsburgh is deliberately fencing it off. The Allegheny River is just as important as the Monongahela, but the Monongahela has developed and made Pittsburgh. You fence off the Allegheny, which is just as important. I can't understand it, and I have been watching it a good many years. Go on the Point bridge and look up the river and you would think the bridges were deliberately planned to shut off the river.

In regard to the steamboats, I have examined steamboats in all countries and the stern-wheel steamboat on the Ohio River handles traffic more cheaply than any other craft in the world. Then why should you change the form of the river craft?

I believe there is plenty of opportunity to develop your wharf to great advantage by adopting Mr. Morse's plan. I do not see why the plan is not compatible with the interests of the Pennsylvania Railroad and the street-car lines and the river shipping. I do not see how any of them would suffer.

MANUFACTURE OF SEAMLESS STEEL TUBING*

By W. C. Chancellor†

The remarks contained in this paper will be confined to the manufacture of seamless steel tubes by the rotary piercing process, as distinct from the cupping process and the hydraulic piercing of solid slugs. The methods and equipment described are essentially those in use at the Ellwood City works of the National Tube Company.

The manufacturing of the steel for seamless tubing up to the bloom conforms to general steel-making practice in every respect. In the flow sheet of the iron and steel manufacturing operations, the diversion of the bloom to the solid round for the rotary piercing of seamless tubes marks the first step in the latter process.

The size and weight of the bloom are selected with a view to the weight and size of the seamless tubing it is intended to make. The bloom yard is illustrated in Fig. 1 and the bloom charger in Fig. 2. The bloom is charged into a reheating furnace, which may be of either the continuous or regenerative type. Following the heating, the bloom goes to a bar mill (See Fig. 3), where it is rolled to a round billet. The round is cut to a definite weight (See Fig. 4). The diameter and weight of the round are determined by the intended size, gage and length of the finished tube. The cutting is done on hot saws, and while the round is at a high heat a center mark is made on one end of the round. The centering process is illustrated in Fig. 5. This centering of the round is done to facilitate the entering of the piercing point in the subsequent piercing operation. An inspection of the rounds is made as soon as cooling will permit. All steel and mill defects which will interfere with the quality of the finished product are removed at this point by chipping. The storage of centered rounds is shown in Fig. 6. The round is now ready for charging in the piercing-mill furnace.

At the Ellwood works of the National Tube Company a sloping-hearth furnace is used. It is of the continuous producer-gas fired type. The proper heating temperature for piercing varies with the analysis of the steel and will range from 1200 degrees C. for high-carbon and alloy material to 1350 degrees C. for very mild steel.

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To the general public the most interesting phase of the seamless process is the piercing of the round billet. Before taking up the equipment used in piercing, it is advisable to consider the action on a round section of plastic material when the section is subjected to lateral pressure on two sides and at the same time is subjected to cross rolling. Fig. 7 illustrates this condition diagrammatically. A particle of metal at the center of the original round section travels in a path indicated by the line in the lower diagram, when subjected to cross rolling. From this it is seen that a tendency to rupture exists between any two particles which are near the center. All types of rotary piercing mills are designed to produce just this action on the round.

Fig. 1. Bloom Yard.

It is of historical interest that the modern piercing mill is the result of an attempt to design a straightening machine with crossed rolls which exerted considerable pressure on the solid bar which they were intended to straighten. The designer of this machine, a German named Mannesman, found that some bars straightened on this type of machine contained what was thought at first to be a pipe resulting from the steel-making process. Subsequent investigation showed, however, that this defect in the center of the bar was actually a fracture induced by the peculiar action of the straightening rolls. Mannes-

man followed up this discovery and developed the Mannesman roll-type piercing mill, which, in principle, is the most common type of the rotary piercing equipment in use to-day. A diagrammatic sketch of the Mannesman roll-type piercing mill is shown in Fig. 8.

Fig. 2. Bloom Charger.

Fig. 3. Bar Mill.

The tendency of a heated bar to rupture when worked as previously explained, can, under proper conditions, be used to produce a small and irregular hole approximately 1/8 to 1/4 of an inch in diameter

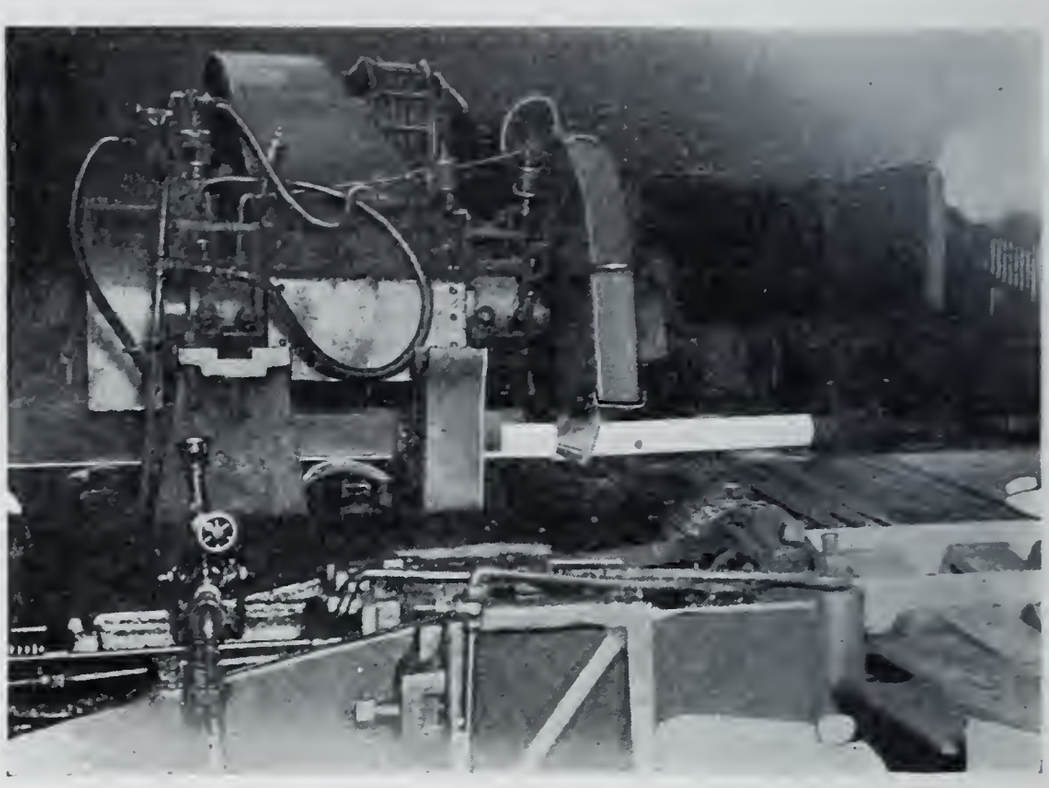

Fig. 4. Cutting Definite Weight of Round Billet.

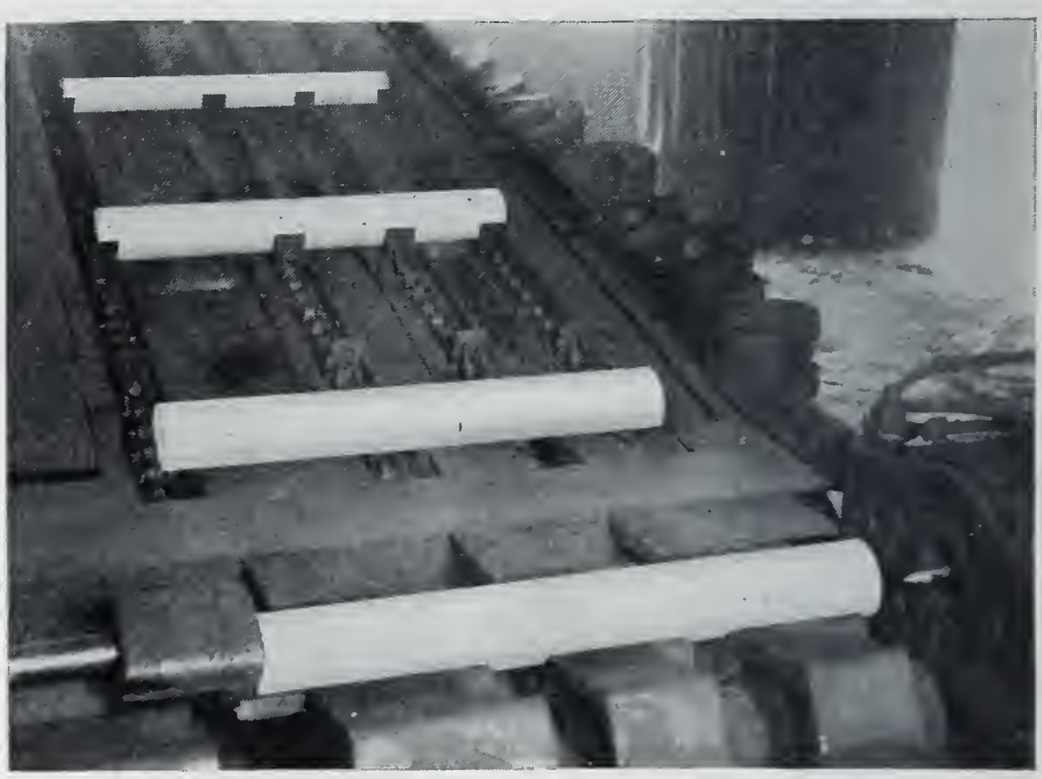

Fig. 5. Marking Center on End of Round Billet.

along the axis of the round. By properly locating a piercing point between the rolls as shown in the diagram, this tendency to rupture can be augmented and taken advantage of. The entering round will

Fig. 6. Storage of Centered Rounds.

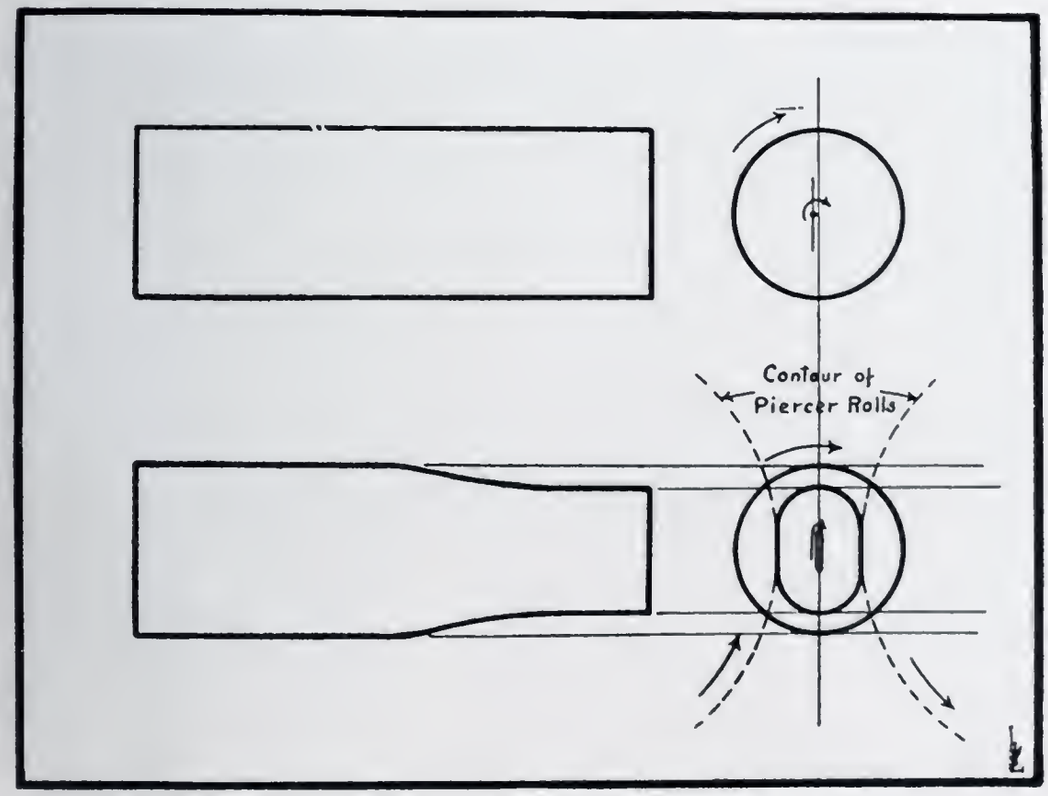

Fig. 7. Diagram Illustrating Effect of Cross Rolling.

be fed over this piercing point at a rate which depends on the angular relation of the axes of the two rolls. The greater the angle the greater the feed.

Following the development of the Mannesman roll-type piercer, the disk type was developed and is in use together with the former

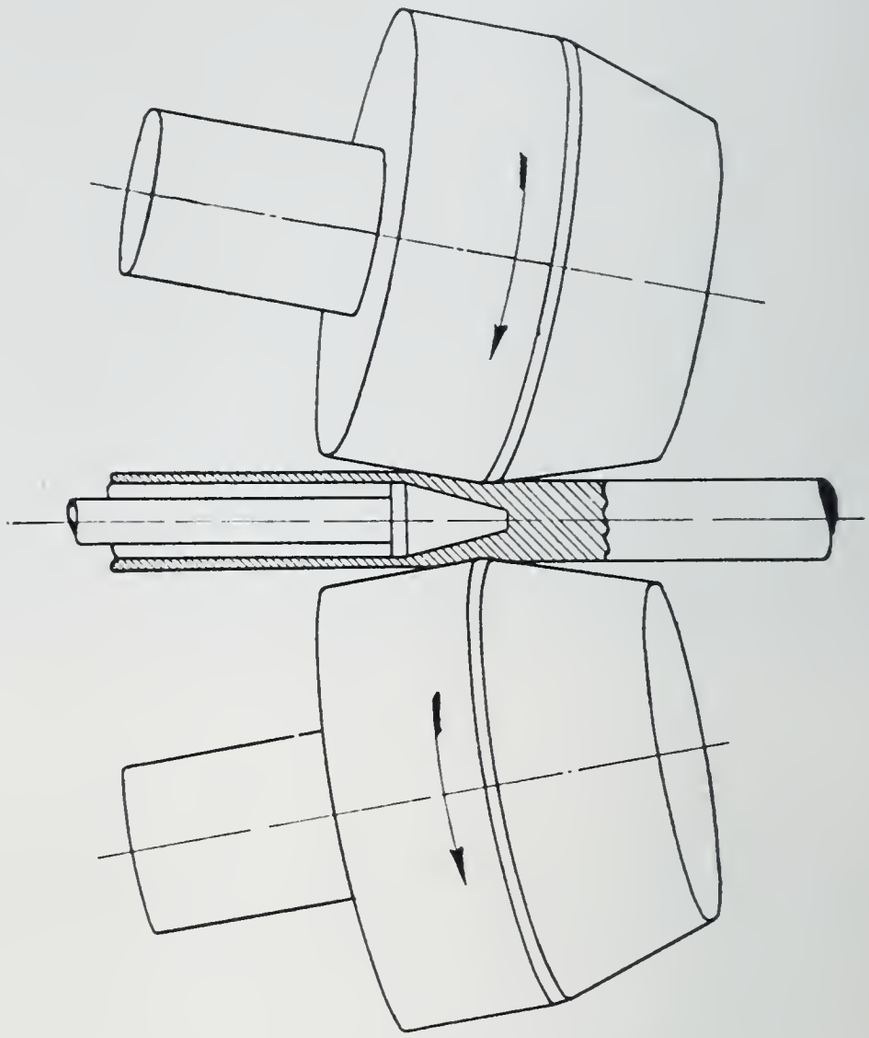

Fig. 8. Sketch of Mannesman Mill.

type. The principle of the disk-type piercer is illustrated in Fig. 9. The angular relation of the disks and the relative position of the round with respect to the center of the disk produce substantially the same conditions as are produced in the rolls of the Mannesman type. The comparative advantages of these two types of piercing mill are of a nature to interest the manufacturer rather than the consumer of seamless tubes. Both types are in use at the Ellwood works, and each type has its peculiar advantage for the particular class of work on which it is used.

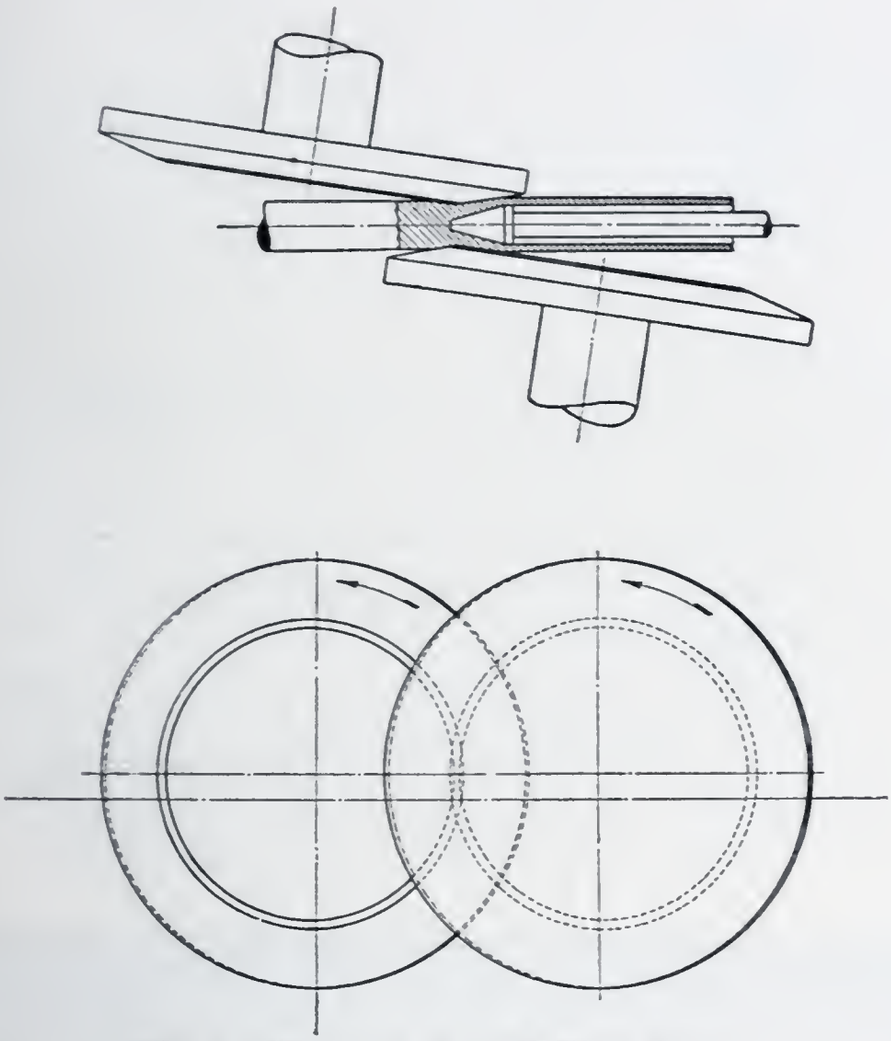

Fig. 9. Diagram of Disk-Type Piercer.

Fig. 10. Solid Billet Entering Piercing Mill.

The driving mechanism of a piercing mill must be capable of delivering the maximum power in a relatively short time. When it is considered that an eight-inch round, three feet three inches long, weighing approximately 550 pounds, is transformed in 18 to 20 seconds to a hollow cylinder nine inches in outside diameter, 16 feet long, and with a wall ⅜ of an inch thick, some conception of power demand and the quality of steel required to withstand this punishment can be realized. One of the chief fundamental arguments for the quality of seamless steel tubing is the fact that only the very highest quality of steel will successfully withstand the piercing operation, for any inherent steel defects will be made immediately apparent. The quality and nature of the various steels suitable for making seamless tubing will be discussed later.

With respect to the finished tubular product, the pierced billet possesses a rather rough surface, considerably heavier wall, and a fairly round cross-section. Fig. 10 shows the solid billet entering the piercing mill, and Fig. 11 the pierced billet leaving the mill.

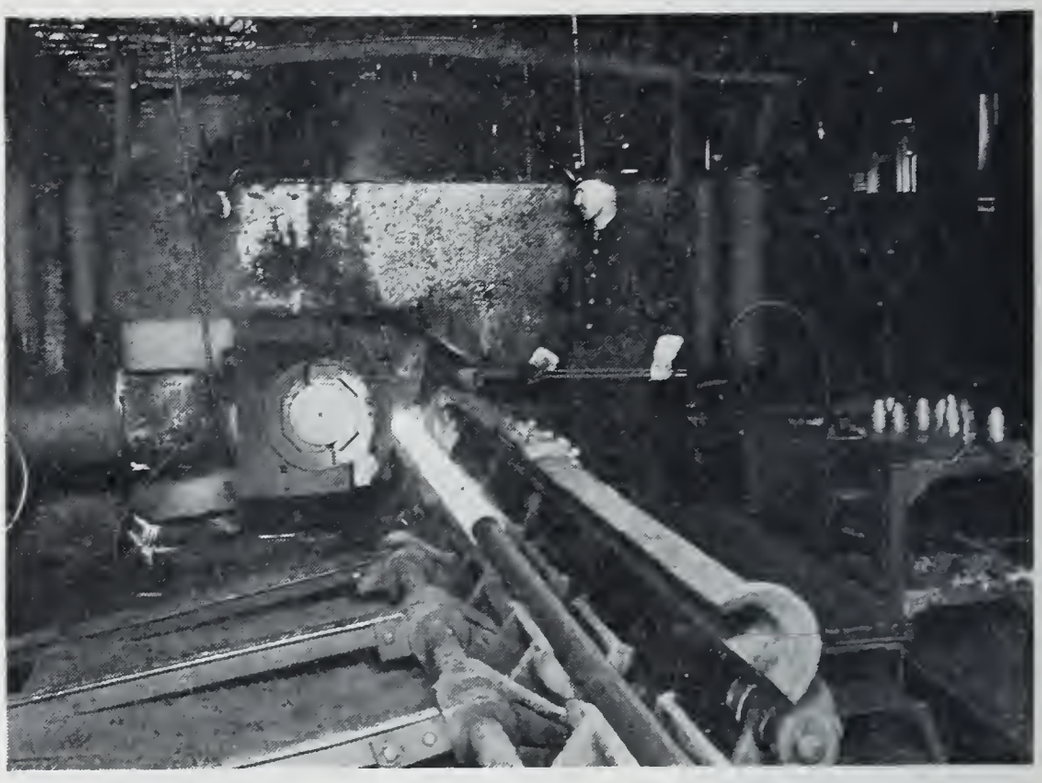

Fig. 11. Pierced Billet Leaving Mill.

Immediately following the piercing operation, the pierced billet is delivered by gravity to the automatic rolling-mill. The basic principle of the rolling-mill is illustrated in Fig. 12. The pierced billet

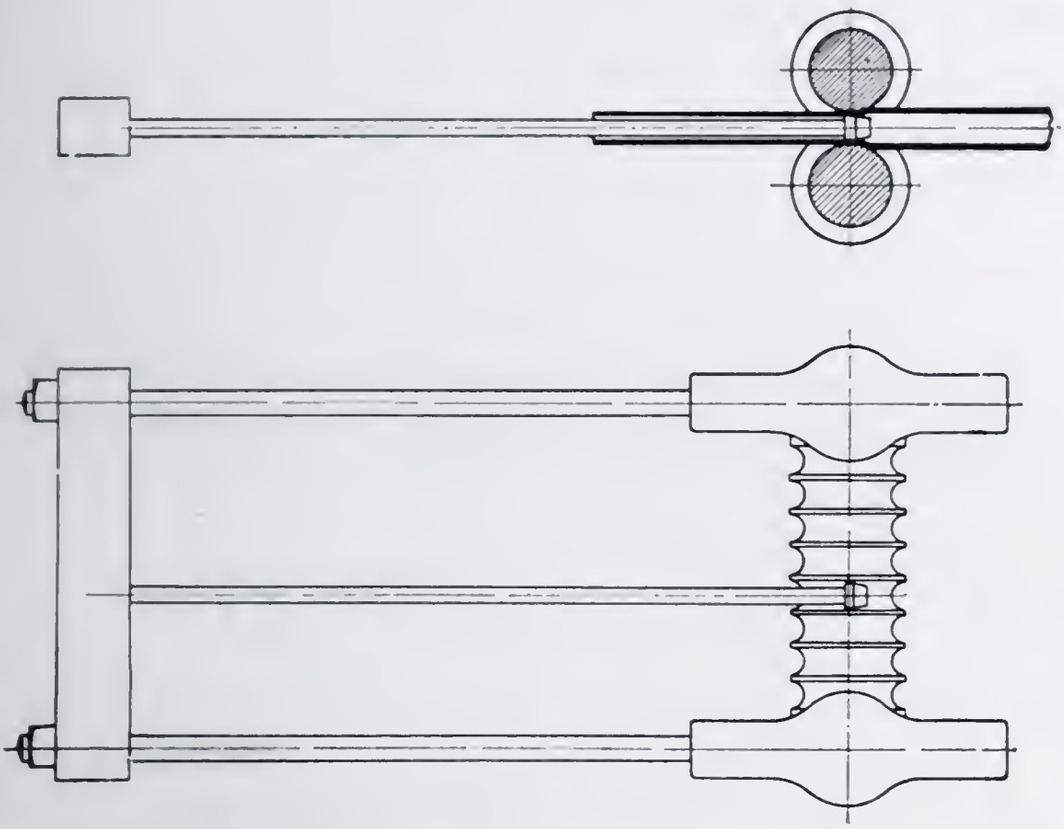

Fig. 12. Diagram of Automatic Rolling-Mill.

Fig. 13. Automatic Rolling-Mill.

is rolled between the circular grooves of the rolls. A long bar supports the rolling-mill plug or mandrel in the roll pass. Due to the pressure exerted on the walls of the pierced billet by the rolls and the

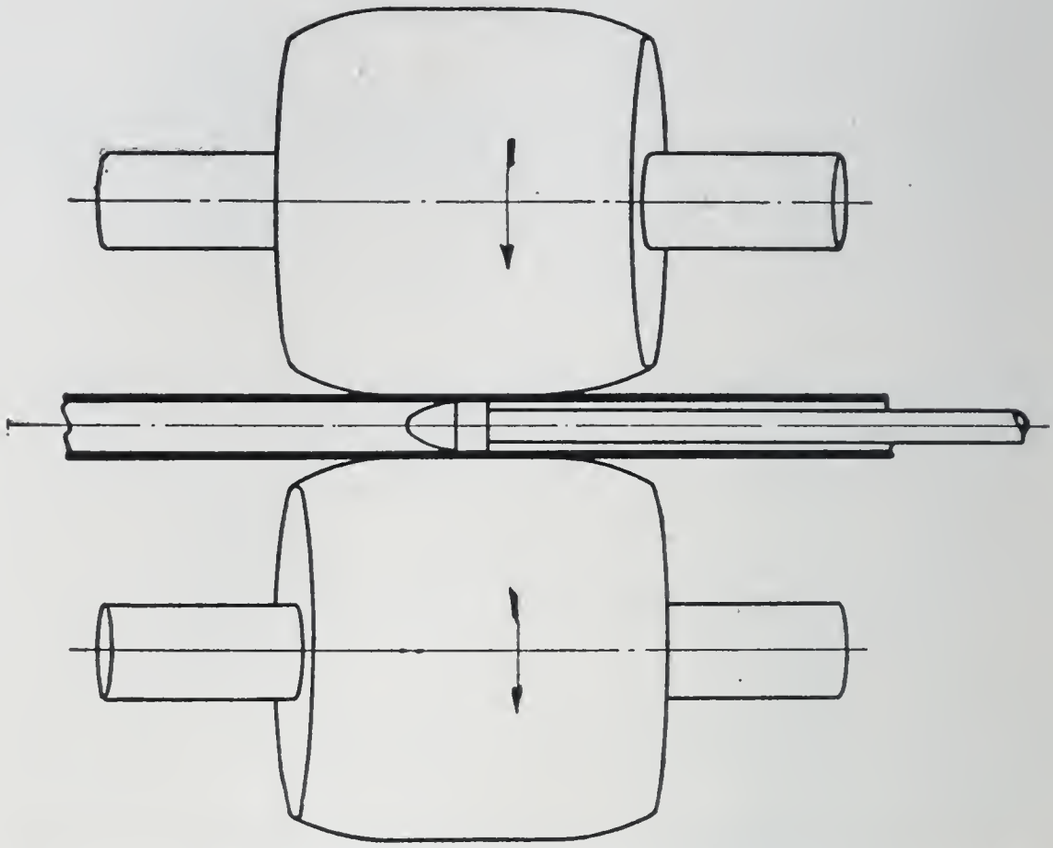

Fig. 14. Diagram of Reeling Machine.

Fig. 15. Tube Entering Reeling Machine.

plug, the tube is reduced somewhat in diameter and very materially in wall thickness, with attendant increase in length. The function of the modern automatic rolling-mill is to reduce the wall thickness

to a point beyond that which is practicable in the piercing mill. It also makes the wall more uniform. Fig. 13 shows a view of the rolling-mill. The product as it leaves the rolling-mill is comparatively rough on the surface and not very uniform in diameter, but the wall or gage is determined by this operation.

When the tube has been rolled to the gage desired it passes at once to the reeling machine, which is illustrated diagrammatically in Fig. 14. The reeling machine is somewhat similar in action to the piercing mill, except that the sides of the rolls are parallel, thus increasing contact surface. The rolls, being crossed at a slight angle, tend to feed the tube over the reeler plug, and the action of the rolls and the plug, when in contact with the wall of the tube, tend to iron out such surface irregularities as remain from the piercing and rolling operations. Fig. 15 shows a tube entering the reeler. The tube on leaving the reeling machine has a very smooth and burnished appearance and is slightly larger than the finished diameter required.

The operation following the reeling is that of sizing. Sizing may be of two types; first, simply sizing between one or more pairs of rolls in order to secure a tube sufficiently round to meet the purpose for which intended. The second type of sizing equipment is known as a

Fig. 16. Tube Passing Through Sizing Machine.

sinking machine. It has been found impractical to produce pierced and rolled tubes of a relatively small diameter. For this reason, the smaller diameters of hot-rolled seamless tubing are secured by means of the sinking machine. This consists of a number of pairs of rolls set alternately at right angles to each other, the grooves in each succeeding pair of rolls being slightly smaller than the former. In this way a rolled tube of about three inches in diameter may be reduced to less than two inches. A continuous reheating furnace is sometimes employed between the sinking mill and the reeling machine. The greater part of the heat in the tube at the sinking operation is, however, the residual heat from the piercing-mill furnace. Fig. 16 shows a tube at the sizing mill. The sinking machine or sizing machine delivers the tube to the cooling table at a temperature from 700 to 900 degrees C., depending on the thickness of the wall section.

Fig. 17. Hot-Finished Tube on Cooling Table.

Reviewing the various operations in the production of a hot-rolled seamless tube with modern equipment, it will be noted that each machine and each stage in the process is designed to accomplish only one step in the transition from the solid round to the finished tube, leaving each succeeding step to be accomplished by the next oper-

ation. The piercing mill converts the solid cylinder to a hollow cylinder; the rolling-mill produces the required wall on the cylinder; the reeling machine eliminates the roughness of surface incident to the two preceding operations; and the final sizing, or sinking and sizing, produces the tube with the proper diameter. Fig. 17 shows the hot-finished tubes on the cooling table.

The terms "hot finished" and "cold drawn" are familiar to most users of seamless tubing. The exact distinction between these two types of product is not, however, generally understood. The steps in the manufacture of the hot-finished and cold-drawn products are exactly the same up to the point of delivering the hot-rolled tube to the cooling table. After this hot-rolled tube is straightened, cut to length and inspected, it is ready for the market as a hot-rolled or hot-finished tube. If, however, it is sent to the cold-draw department from the cooling table, it may be put through various cold-draw operations and be ultimately finished as a cold-drawn tube.

Returning to the hot-finished tube on the cooling table, it receives, when cool enough, a preliminary inspection for outside diameter and outside defects. It is then straightened on any one of a number of types of straightening machine. Fig. 18 and 19 show two types of straightening machines. The next operation consists of cropping the

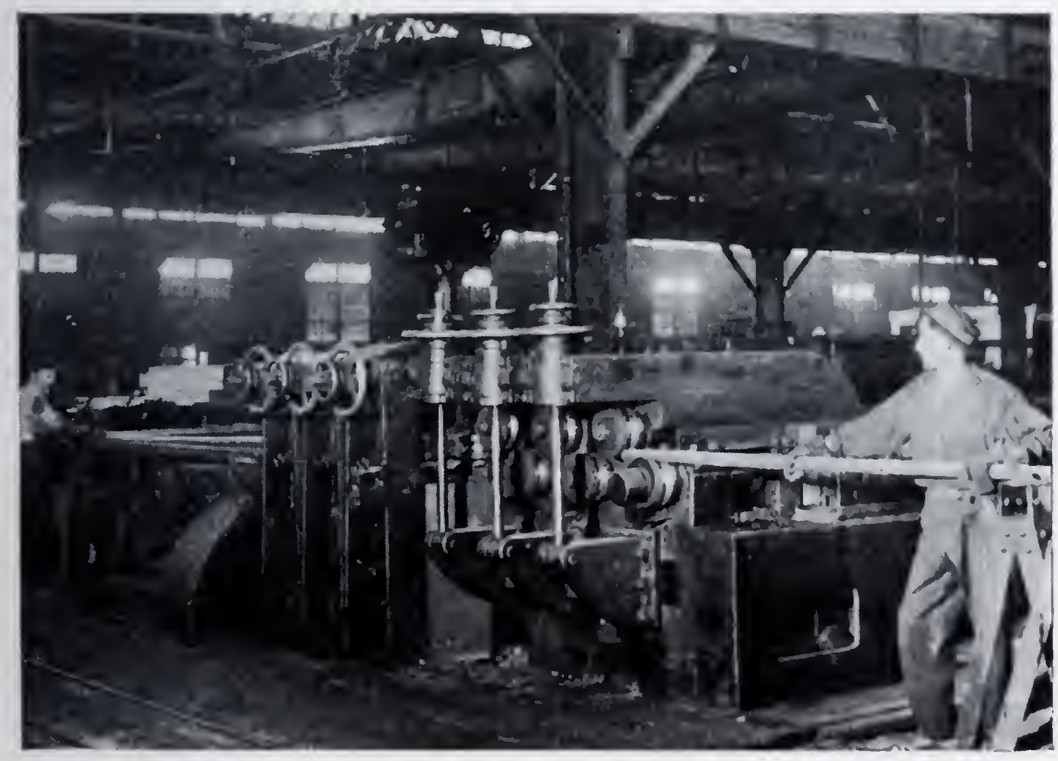

Fig. 18. Straightening Machine.

rough ends of the tube and obtaining the desired length. This is done in a cut-off machine, which is shown in Fig. 20. Following the cutting to length, the tube is given a final inspection, which includes

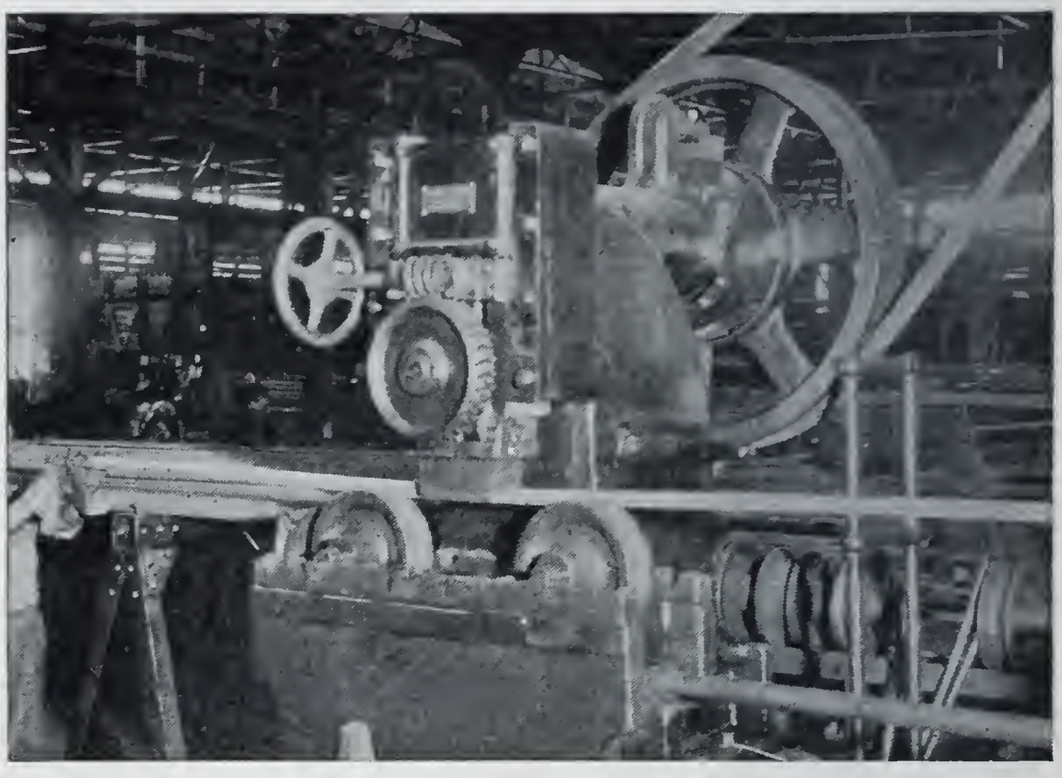

Fig. 19. Straightening Machine.

Fig. 20. Cut-Off Machine.

checking the diameter, gaging of the wall, and inside and outside surface inspection. This final inspection is followed by a hydrostatic test in the case of boiler tubes, pipes and other tubes intended to withstand fluid pressure. On tubular products made by any of the welded processes the hydrostatic test is a very important step in the inspection, as it serves to detect imperfect welds and joints, which often can not be detected by visual examination. The absence of such welding or joints in the seamless tube places the hydrostatic test as an extra precaution, for such tubes as fail on the hydrostatic test invariably present visual surface defects which can be detected in the ordinary surface inspection.

Returning again to the hot-finished tube as delivered to the cooling table, we will assume that it is desired to produce from this hot-finished tube a cold-drawn tube of some smaller cross-sectional area. This will be accomplished by drawing the tube through a die somewhat smaller than the diameter of the original tube. Fig. 21

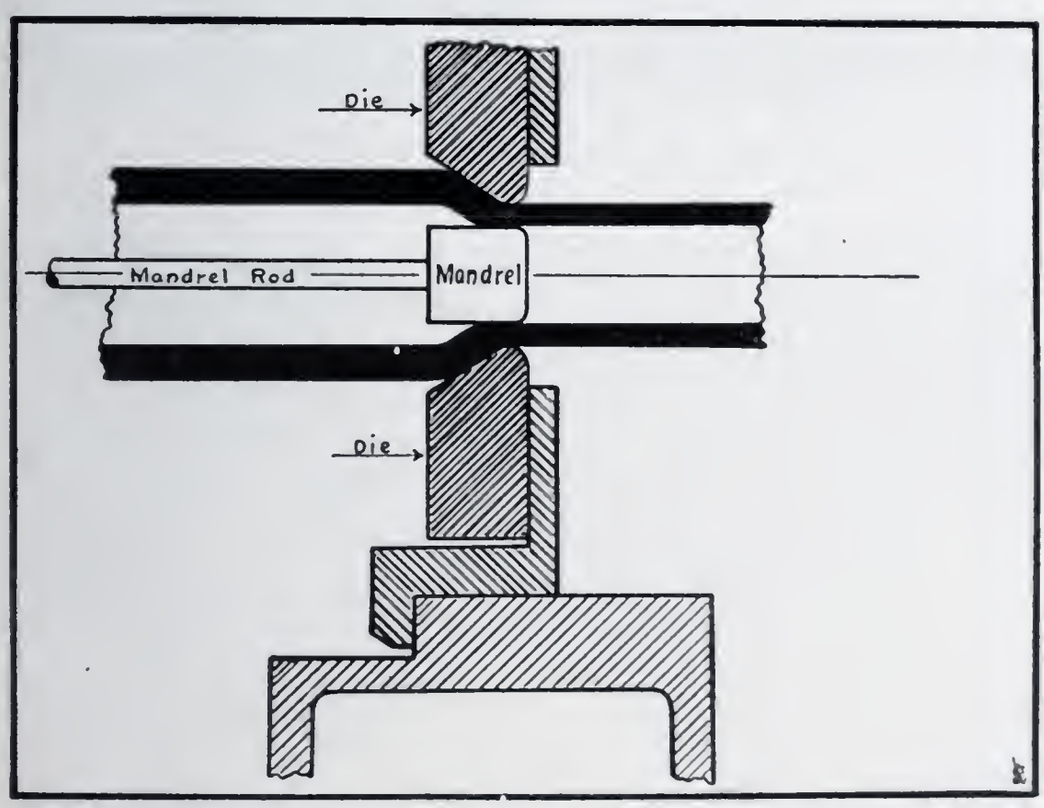

Fig. 21. Relative Position of Die and Mandrel in Manufacture of Cold-Drawn Tubes.

illustrates the relation of the tube and die. In most cases a mandrel is placed inside the tube in conjunction with the die. This mandrel

is located in the die and supported there by a long rod. Fig. 22 and 23 illustrate the general character of a draw-bench for seamless tubes. If a mandrel is to be used, its size is such that the space between the die

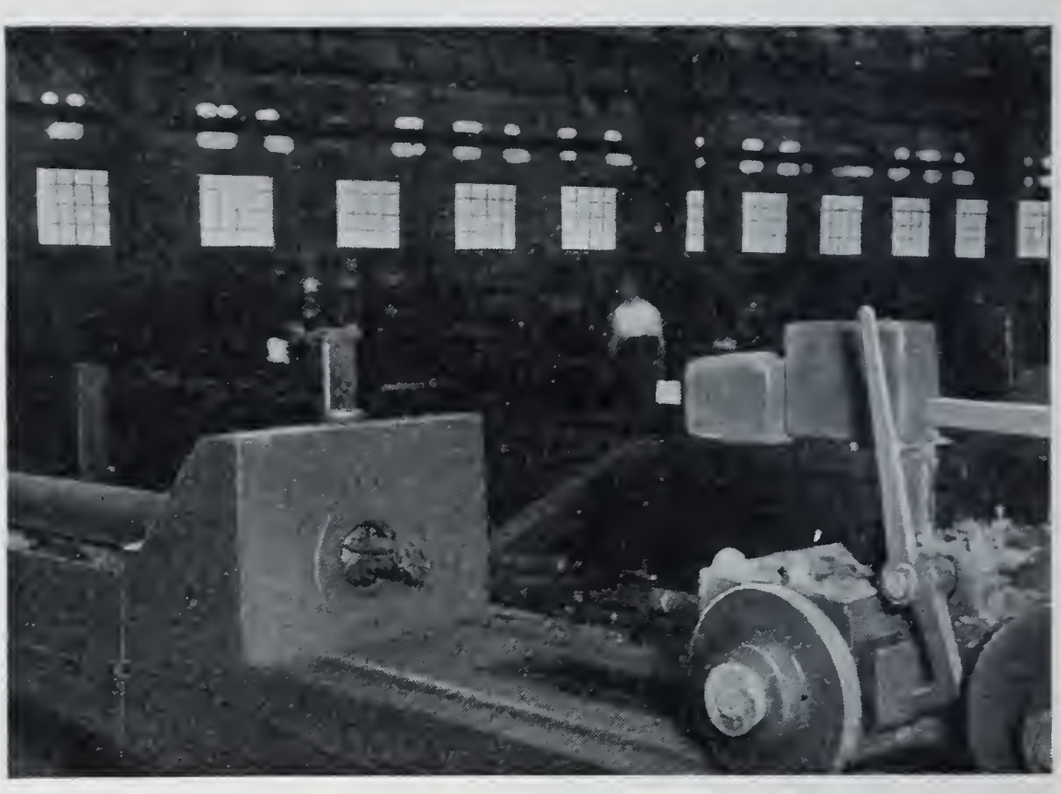

Fig. 22. Draw-Bench for Seamless Tubes.

Fig. 23. Draw-Bench for Seamless Tubes.

and the mandrel is less than the wall of the tube to be drawn. When the tube is drawn through the die under these conditions, it is apparent, of course, that the wall as well as the diameter of the tube is reduced. Preliminary to cold drawing, the tube must be pointed on one end for a distance of four to six inches in order that sufficient length of a reduced diameter may protrude beyond the die and permit the pliers of the bench to secure sufficient grip to draw the remainder of the tube through the die and over the mandrel. This pointing is done with the ordinary type of swedging hammer. Following the pointing the tube is sent to the pickle tubs, where all scale adhering to the tube is carefully pickled off. The tube is then rinsed to eliminate the acid and is dipped in the lubricant or "dope," the purpose of which is to reduce friction and prevent metal to metal contact between the tube on one side and the die and mandrel on the other. The actual drawing of the tube is done by means of the draw-bench chains and the pliers or grips which can be hooked into the chain after they have grasped the point of the tube. Fig. 24-26 illustrate the pointing and

Fig. 24. Pointing of Tube for Cold Drawing.

drawing of the tube. The drawing is accomplishd at a speed varying from 25 to 60 feet per minute, and the reductions in cross-sectional area for one cold-draw pass will vary from 15 to 45 per cent. The

successful cold drawing of a seamless-tube section is rendered much more difficult than the drawing of a solid section such as wire or shafting, owing to the fact that the internal surface of the tube presents material difficulties in the matter of proper cleaning in pickling, lubrication, and additional friction surface.

From the previous remarks relating to the amount of cold work in the process of cold drawing, it is apparent that a tube, after drawing, possesses considerable mechanical hardness. This mechanical hardness is almost directly proportional to the reduction of area resulting from the cold-draw pass. As a desired size of cold-drawn

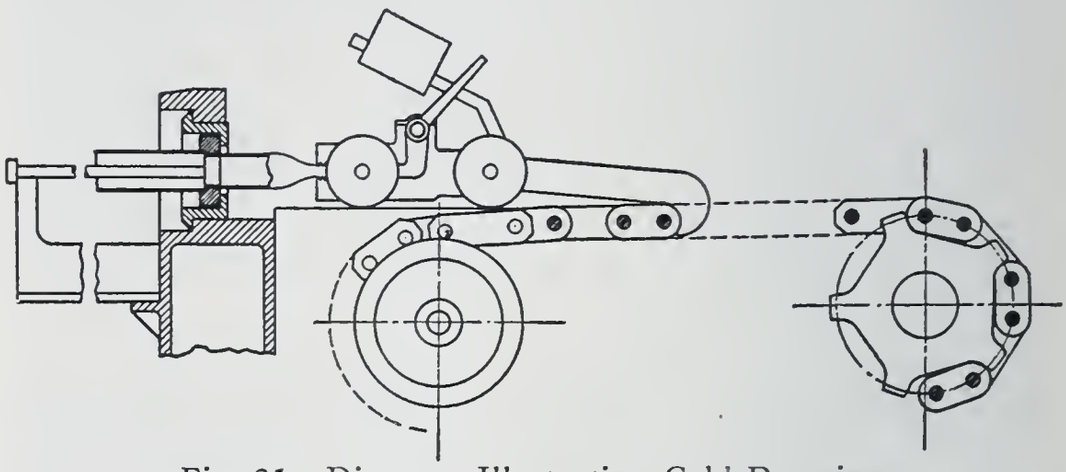

Fig. 25. Diagram Illustrating Cold Drawing.

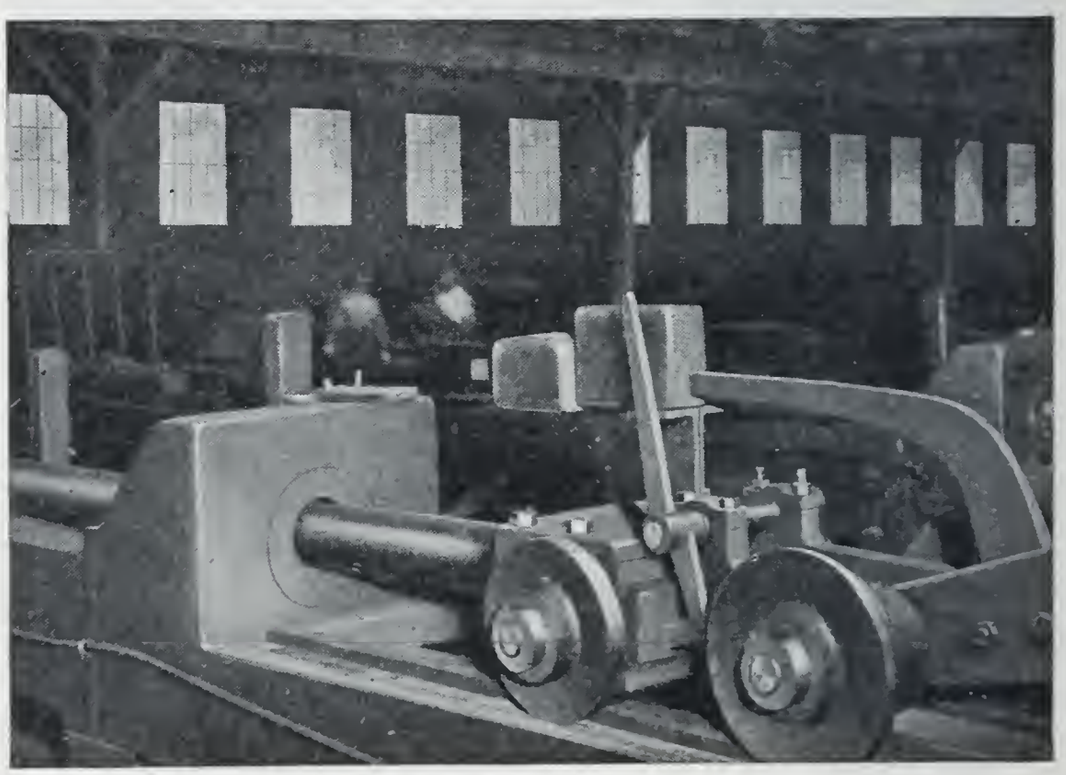

Fig. 26. Cold Drawing.

tube in the smaller diameters can not be produced in one pass from the original two-inch diameter hot-rolled tube, a number of cold-draw passes are often necessary. Owing to mechanical hardness resulting from the preceding pass, it becomes necessary to anneal the tube after the first pass before it can again be drawn successfully. The effects of temperature in relieving this mechanical hardness will be discussed later. In general, temperatures of 700 to 800 degrees C. are employed for annealing between passes. Two types of furnaces are employed. The most common type, which is used on material relatively heavy in cross-section, is of the coke-fired open type in which the work is exposed to the soft flame of a coke fire. The other type of furnace is used on material required to be dead-soft anneal. It is also used for the annealing between passes of material 16 gage and lighter. In this latter type of furnace the work is packed in steel retorts, which are sealed and then are gradually worked through a continuous furnace. In this way the work is brought gradually to the full furnace temperature, maintained for the required time and cooled over a long period. The result of this type of annealing is maximum softness and ductility, together with a minimum of scale from oxidation and pitting of the surface. When the required size of tube has been obtained by one or more cold-draw passes, the tube is given a final annealing, the annealing temperature being selected to give the necessary physical properties for the purpose intended.

Touching briefly on the uses and applications of seamless tubing, these uses naturally divide themselves into two groups. In the first group are found those which may be considered the usual and expected application of tubular products, that is, for conveying fluids. Under this group will appear boiler tubes and flues and the various grades of pipe and oil country tubing, which are produced in considerable quantity in seamless types. Of recent years the intensive methods of production and refining of petroleum, with the consequent increased mechanical requirements, have brought about a substitution of seamless tubular products for welded products in both the oil country and petroleum refining industry. The same causes—that is, increased demand and heavy duty—have developed a great tonnage of seamless boiler tubes where formerly welded goods were used. Likewise, in the field of special and standard pipe where the safety hazard has been great or the service demand unusually heavy, seamless material has

supplanted welded material. This first general group of uses constitutes the greater part of seamless tonnage.

The second group, while not so large, offers considerable interest from an engineering standpoint. It is customary to include under the term "mechanical tubing" all of those various applications of seamless tubing where the tube, due to cross-section, lends itself to the construction of machinery or machine parts. The annular cross-section of the tubing may be desirable because of its great stiffness and strength as compared with an equivalent solid section. It may be desirable because its peculiar cross-section lends itself to the design in question. The use of a hollow original section often reduces or eliminates the machining required to adapt a solid section to a given use.

The chief market for mechanical tubing is in the automobile industry, the reason being, of course, that in this industry a maximum of strength with a minimum of weight is essential. Likewise, the intensive production which is characteristic of this industry demands raw material which can be produced accurately to size and which can be fabricated with little or no machining.

While the automobile industry absorbs the greater part of the mechanical tubing produced, it is a fact that seamless tubing finds its way into a greater variety of machinery and appliances than any other similar product. These miscellaneous applications range from recoil cylinders on field guns to fishing rods, from golf shafts to fighting tops on battleships, from diamond-drill equipment for deep mining explorations to structural members in air craft, and from centrifugal separating machines to textile-weaving machines.

In this paper it is not intended to discuss specifications and specific requirements of seamless tubular products, but it would be of interest to mention the accuracy of size and the various qualities of tubing which may be expected in commercial production. Hot-rolled tubing can be produced in the smaller sizes, that is, from two to three inches in diameter, within a tolerance of 0.031 of an inch on the outside. This variation is less than the usual practice on ordinary pipe and applies only to hot-rolled mechanical tubes when specified in sufficient quantity to permit the adjustment of equipment to meet this tolerance. The larger sizes can be produced with an outside tolerance of 0.046 to 0.062 of an inch, depending on the size and the wall. When the wall of the tube becomes relatively light in proportion to

the diameter, difficulty is encountered, due to ovalness, which results from straightening and handling. The surface of a hot-rolled tube is comparable with the surface of any other similar hot-finished product.

It is customary to limit the variation in wall thickness or gage of seamless tubing on a percentage basis. This is due to the fact that the conditions under which the billet is pierced do not necessarily permit the piercing point to follow exactly the axis of the round being pierced. As a result, eccentricity, to a greater or less extent, is always present in any tube made by the rotary piercing process. It has been found by experience that the logical means of limiting eccentricity in the finished product is by limiting the variation to a percentage of the nominal wall. In addition to pure eccentricity—that is, eccentricity of the outside diameter and inside diameter—there will be found in a hot-rolled tube a slight additional wall variation which results from errors in rolling. The heavy and less delicate equipment used in producing a hot-rolled tube as compared with cold drawing does not permit of the refined adjustments possible in cold drawing. Summing up the question of wall variation and eccentricity, it may be stated that the eccentricity of a cold-drawn tube will be, on an average, about five per cent. of the wall, and will not exceed 10 per cent. at the maximum. The errors in rolling referred to in connection with hot-rolled tubes will necessitate about two to three per cent. greater variation in wall than in the cold-drawn product.

The diameters of a cold-drawn tube, both inside and outside, can be controlled within very close limits. On tubes having 1.5 inches outside diameter and smaller, a maximum variation of 0.005 of an inch can be expected. This variation increases with increasing diameter until, at five inches outside diameter, the maximum variation would be about 0.015 of an inch. The surface of a cold-drawn tube is smoother than that of a hot-finished tube and is comparable with the surface of any other cold-drawn steel product. The cold-drawn product lends itself particularly to those requirements where tonnage is not great and surface appearance and extreme accuracy of size are important. Additional possibilities are afforded in cold drawing, as compared with hot rolling, in the matter of physical properties; for, within limits, the physical properties of a given cold-drawn tube may be varied by the degree to which the mechanical hardness of cold drawing is eliminated in the final annealing operation.

On the other hand, hot-rolled tubing is best adapted to those applications requiring larger tonnage and where speed of tube production is an important item. The matter of physical properties can be met successfully in the hot-rolled tube by varying the analysis of steel used, and in case this does not afford sufficient latitude, heat treatment can be adopted, as hot-rolled tubing lends itself particularly to heat treatment. The wide range of tensile properties possible in a given steel, when cold drawn and partially annealed, may at first appear to be an additional advantage; but, when it is remembered that such increase in tensile strength is always made at the expense of ductility, it becomes very doubtful if any material advantage has been gained over the normal tensile strength and normal ductility which are to be expected in the hot-rolled tube.

Summing up the comparison of hot-rolled and cold-drawn tubing, it may be stated as a general fact that, when the tube is to be machined and a high-surface finish is not required, hot-rolled tubing is to be preferred.

Mention has already been made of the drastic action of the piercing operation on the steel round, and of the necessity of using only steel of the highest quality. Carefully made steel from the basic open hearth, acid open hearth, electric furnace, and crucible furnace are suitable for rotary piercing. Bessemer steel, owing to the greater amount of impurities, both as solid non-metallic inclusions and impurities in combination, does not withstand the piercing operation. In addition, it is not as satisfactory for cold drawing as steel made by the other processes mentioned. Experience indicates that cold-drawn seamless tubing made from Bessemer steel is particularly brittle. The chief requirements of a good steel for rotary piercing are that it be sound and free from pipe and segregation, and free from oxidized surface blow-holes; and that solid non-metallic inclusions be at a minimum. In addition, unusual care must be exercised in the blooming of the ingot to prevent checks, tears, and laps. The requirements as just mentioned are, of course, those of any other steel of good quality, but it is doubtful if an equal tonnage of steel is consumed in any other branch of the industry, in which these requirements must be as rigidly adhered to as in the case of steel for seamless tubing. Segregation and piping become readily apparent after piercing, as such a tube will present a very scabby and torn condition on the inside. Those

defects which exist near the outside of the ingot, even though they are difficult or impossible of detection in the bloom, will manifest themselves in the form of seams, slivers, and scabby outside surface. By the action of the piercing operation, such minor exterior defects are opened up and elongated in a circumferential direction. It is, therefore, apparent that any surface defects which, in the solid section, escape all but the most rigid inspection will become readily apparent after passing through the piercing mill.

It may be of interest to mention the various types and grades of steel which are suitable for rotary piercing. The bulk of the tonnage is produced in the plain carbon grades ranging from 0.10 to 0.40 carbon. Boiler tubes and pipe consume the largest portion of the material of this composition, the remainder going into mechanical tubes. Mechanical tubing consumes the greater portion of the 0.20 to 0.30 carbon range. Oil-country tubular products account for the bulk of the tonnage in the 0.30 to 0.40 carbon range, and the remainder of this carbon range finds its way into mechanical uses. Among the alloy steels, nickel steels with carbon from 0.15 to 0.40 are consumed in some quantity; likewise, chrome-nickel steels and chrome-vanadium steels of low and medium carbon ranges. Among the less workable steels which can be pierced successfully is a grade used in the ball-bearing industry. This grade has been produced in considerable quantity. It contains approximately one per cent. carbon and 1.5 per cent. chromium.

It is not believed advisable in this discussion to mention specific physical properties, as these properties vary so greatly with chemical analysis, size, percentage of reduction in cold drawing, and final annealing temperature after cold drawing, that such a discussion would become very involved. It is of more general interest to discuss the tendencies of these factors.

Considering first the physical properties of hot-rolled tubing, it has been stated that a hot-rolled tube of a given chemical analysis will possess practically the same physical properties as any other hot-rolled section of equal thickness. As these physical properties are generally understood, it remains only to mention the effect of the thickness of the wall on the physical properties. Fig. 27 shows the relation of increasing wall thickness plotted against percentage change in tensile strength and yield-point. The physical properties for each wall thick-

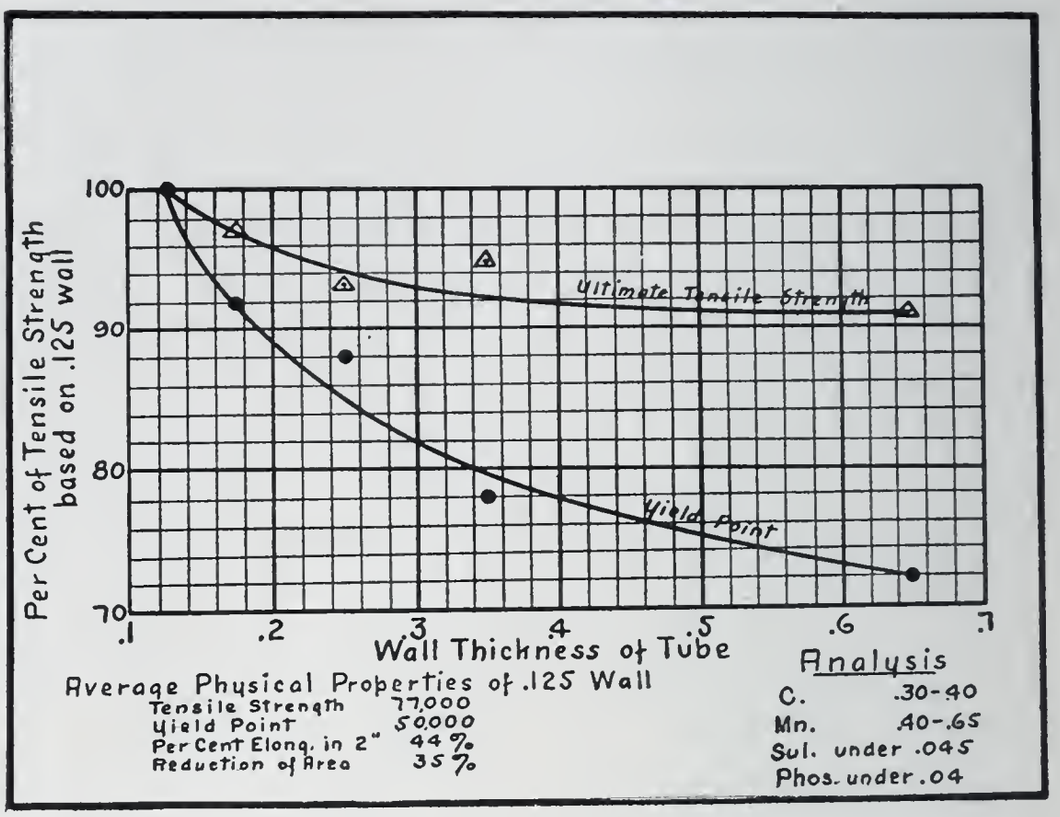

Fig. 27. Effect of Wall Thickness on Physical Properties.

ness are referred to 0.125-inch wall as 100 per cent. It is not generally realized that this matter of wall thickness is of considerable importance in determining the tensile properties of a tube of given composition. If it is realized, however, that a range of wall thickness from 0.125 to 0.625 of an inch is not at all uncommon, and that such a range bears a very similar relation to a range in bar stock from one inch to five inches in diameter, this question of variation in physical properties can be better appreciated. From the diagram it is seen that the effect of a given change in wall thickness on tensile strength is greater for the light walls and becomes less effective as the walls approach the heavier sizes. The same tendency is shown with respect to the yield-point, but the change is *much greater in the yield-point than in the tensile strength.* This is borne out by general experience in heat treatment and annealing. Heat treatment increases the elastic ratio very greatly and the annealing decreases the ratio. The thin-wall tube can be considered as having had an air quench with respect to the slower cooling or annealing of the heavier wall section. Owing to the annular section of the tube and consequent poorer circulation of air in the inside as compared with the outside, it is to be expected that a hot-rolled tubular section will be slightly more ductile and

lower in tensile strength and yield-point than an equal section in the form of plates and sheets.

When the physical properties of cold-drawn seamless tubing are considered, two additional factors must be considered. These are, of course, the amount of cold work done on the tube and the extent to which the effects of this cold work are eliminated by the final annealing operation. The diagram in Fig. 28 illustrates, in a general way,

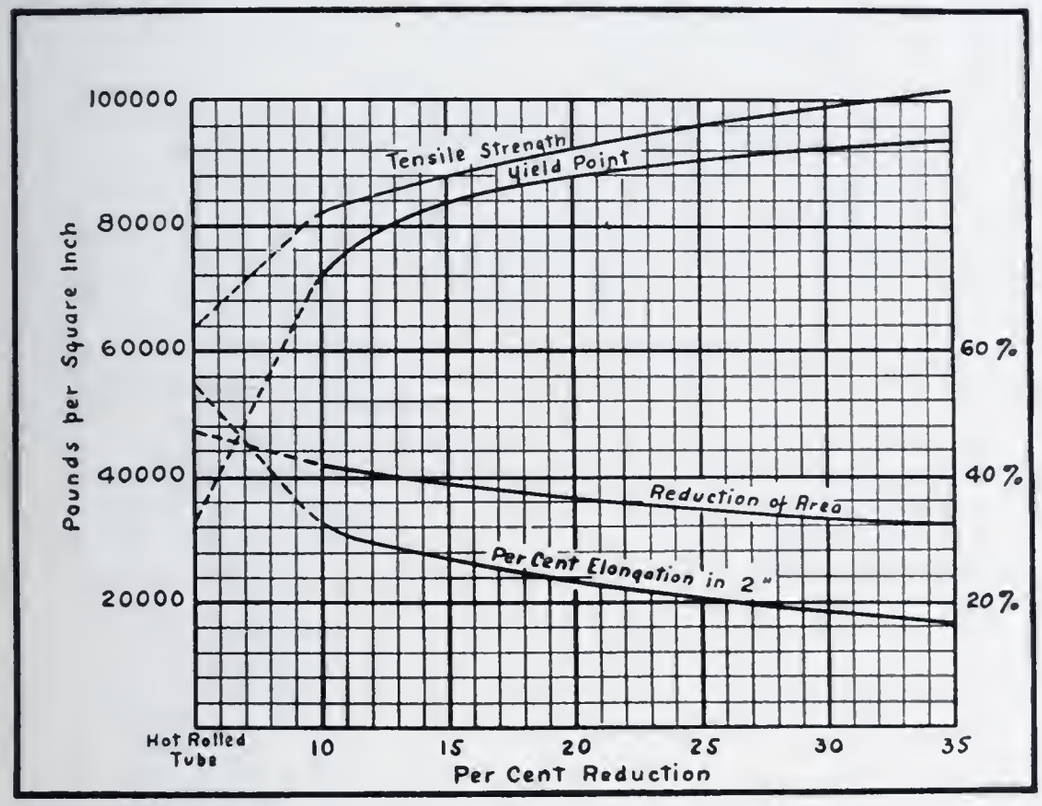

Fig. 28. Effect of Cold-Draw Reduction on Physical Properties.

the change in physical properties of a 0.30 carbon tube, beginning with the hot-rolled condition and followed by various amounts of cold working as measured by the percentage of reduction of the section in drawing. The structure of the metal in the hot-rolled condition may be considered as normal. A small amount of cold work produces a small distortion of the grains which make up the structure. This distortion takes place in the individual grains by means of slip along slip-planes. Once started, slip continues with increasing stress until further slip is opposed by the adjacent particles to an extent sufficient to produce deformation of the crystal along new slip-planes. The distortion of the grains along the slip-planes is proportional to the amount of cold work. As there is a decided healing action on a slip-plane when slip ceases on that particular plane, this results in greater resist-

ance to further slip along that plane. Consequently, a greater force is required to produce further distortion in grains which have been previously subjected to cold work. From the diagram it will be noted that hardness, as measured by yield-point and tensile strength, is increased with increasing cold work and that there is a corresponding decrease in the ductility as measured by the percentage elongation and reduction of area.

The diagram in Fig. 29 illustrates the effect of various annealing temperatures on the physical properties of a cold-drawn tube. In this particular instance, a 0.30 carbon tube has had about 35 per cent. reduction in cold drawing. This curve is plotted from a number of tests. In individual tests of this sort it is frequently noted that an annealing temperature of 400 degrees C. gives a tensile strength and yield-point slightly higher than found in the "green" or the hard-

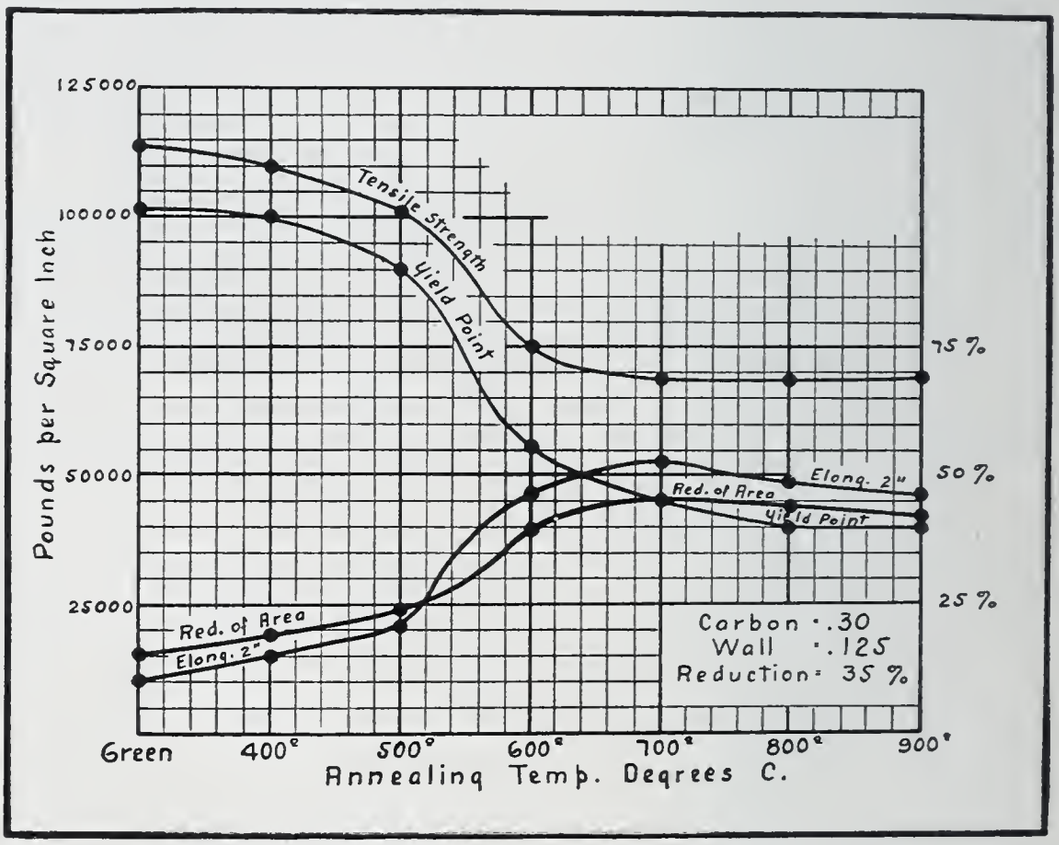

Fig. 29. Effect of Annealing Temperatures.

drawn condition. This is partly due to the healing action which takes place along the slip-bands when the tube is heated to a temperature slightly above room temperature, and partly due also to the fact that internal stresses are removed by this moderate heating. At 500 degrees C. an appreciable relieving of the hardness has resulted, and at 600

degrees a still greater change is produced. From 700 to 900 degrees C. the change in physical properties is slight compared with the changes produced at the lower temperatures. The recrystallization of cold-worked steel and iron begins in the neighborhood of 400 degrees C., and this recrystallization is accompanied by a destruction of the effects of cold working. The recrystallization and destroying of the effects of cold working brings about a gradual restoration of the original physical properties as found in the hot-rolled tube. It is to be noted that the pearlite of the original structure, as well as the ferrite, becomes distorted in proportion to the amount of cold work; and, further, that the effects of gradually increasing annealing temperatures are confined to the ferrite alone and are progressive. The pearlite remains unchanged until the lower critical point is reached in the neighborhood of 700 degrees C. At 900 degrees a complete normalizing has taken place, and both the structure and the physical properties are those of a normalized hot-rolled steel.

In the commercial annealing of cold-drawn seamless tubing it is customary to adhere to standard "tempers" or anneals—namely, green or unannealed; "finish anneal," in the neighborhood of 500 degrees C.; medium anneal, in the neighborhood of 600 degrees C., and soft anneal, ranging from 700 to 900 degrees C., depending on specific conditions. The unannealed tube will, of course, represent a condition of maximum hardness and minimum ductility. Finish anneal and medium anneal possess moderate ductility and moderate hardness. Soft anneal material represents a condition of maximum softness and minimum hardness. In specific applications of cold-drawn tubing it is, therefore, necessary to understand the exact conditions of application in service in order that the proper anneal may be selected. The harder tempers will, of course, stand very little cold forming and bending, and the soft anneal material will be best adapted to these conditions but will not meet the requirements where stiffness and strength are the chief considerations.

The photomicrographs in Fig. 30-36 will serve to illustrate in a general way how the structure is affected by cold working and subsequent annealing. The photomicrographs are confined to 0.10 carbon material, as the effects of cold working are best observed in large masses of ferrite. All are etched in picric acid, and magnified 200 times. It will be noted in Fig. 30 (which is the hot-worked structure) that the grains

of ferrite and pearlite show no directional tendency. Fig. 31 is a section of the same material as the former, but has been given a reduction of about 12 per cent. and has had no subsequent annealing. In this section there is found some evidence of alignment of the grains in a vertical direction as a result of the small reduction. This same sec-

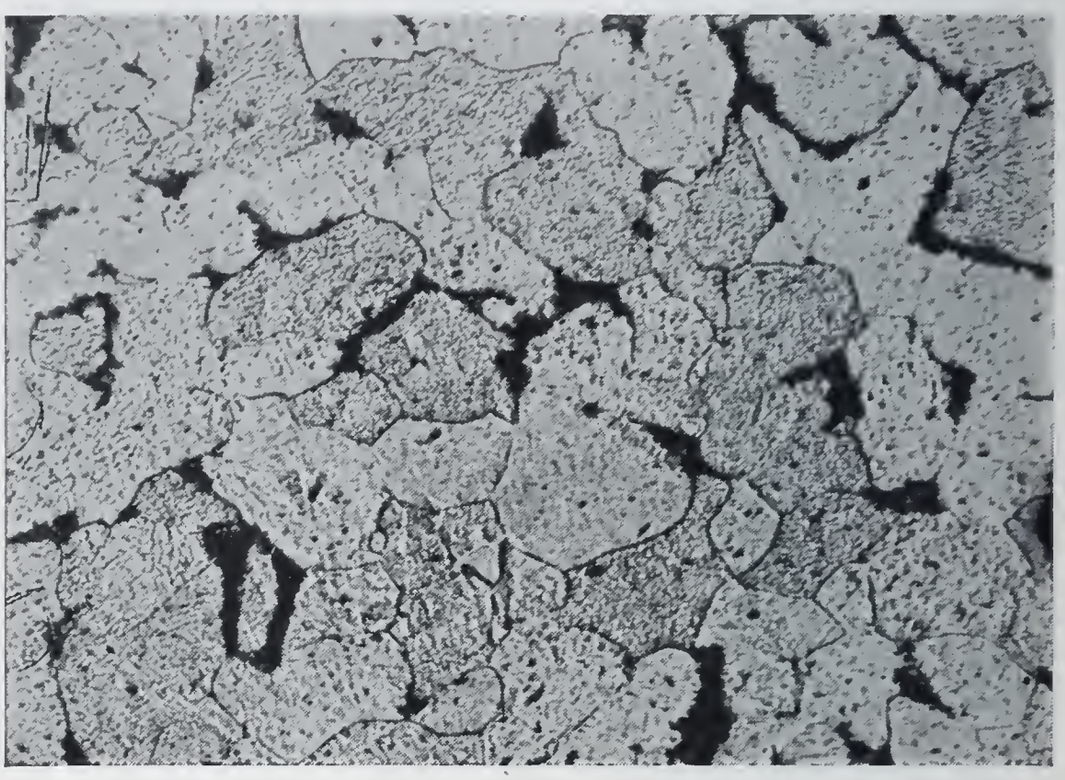

Fig. 30. Hot Worked.

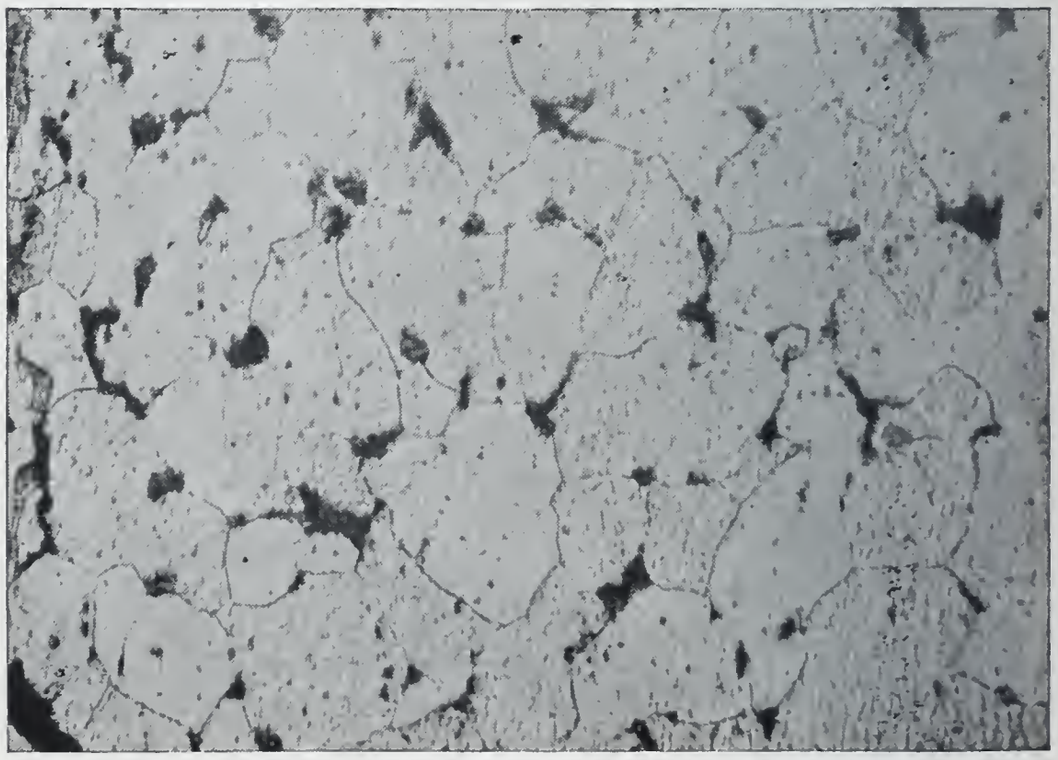

Fig. 31. After 12 Per Cent. Cold Reduction. Not Annealed.

tion will be referred to again in connection with an interesting phenomenon met with under certain conditions in the cold drawing of seamless tubing. Fig. 32 shows the same material after being subjected to a slightly higher cold-draw reduction—about 17 per cent. It is difficult to detect in this particular section any additional evidences of

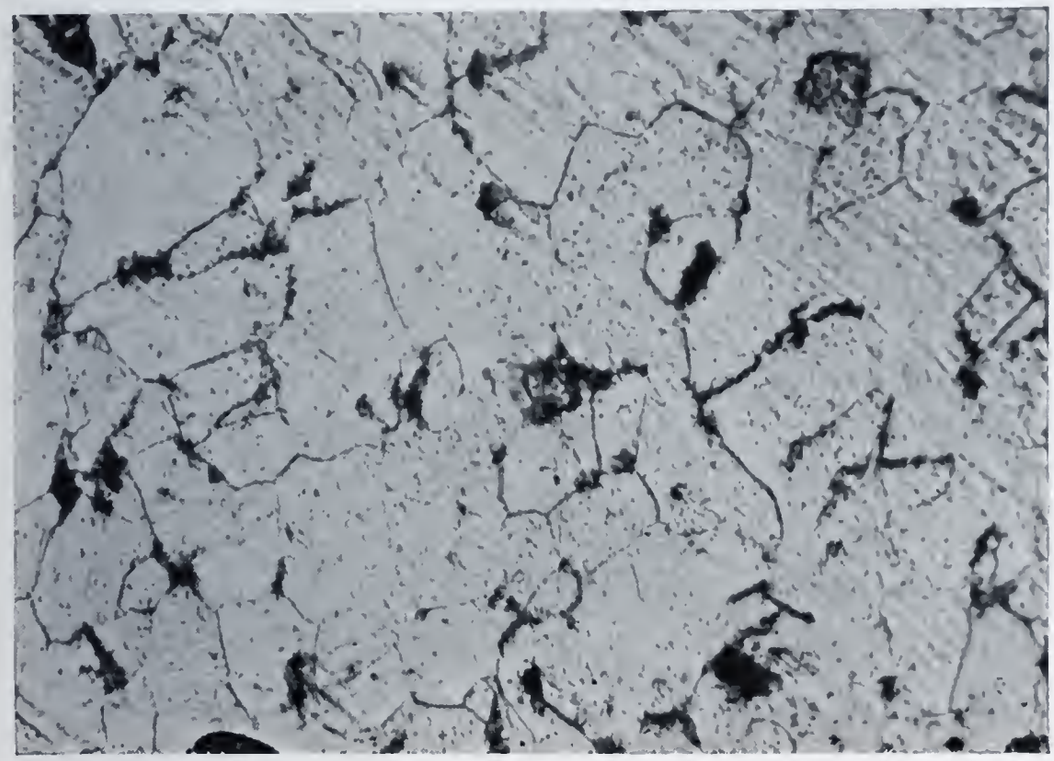

Fig. 32. After 17 Per Cent. Cold Reduction. Not Annealed.

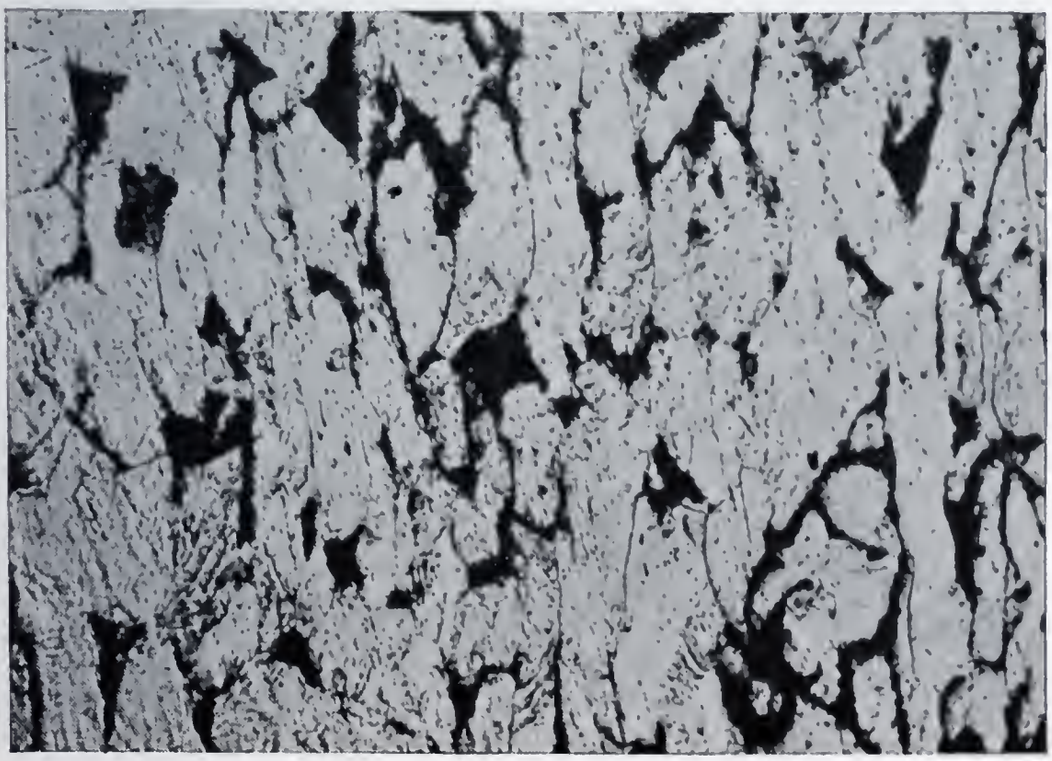

Fig. 33. After 40 Per Cent. Cold Reduction. Not Annealed.

cold work as compared with Fig. 31. Fig. 33 shows the same material after having received a 40 per cent. cold-draw reduction. This relatively large increase in reduction is accompanied by a very radical

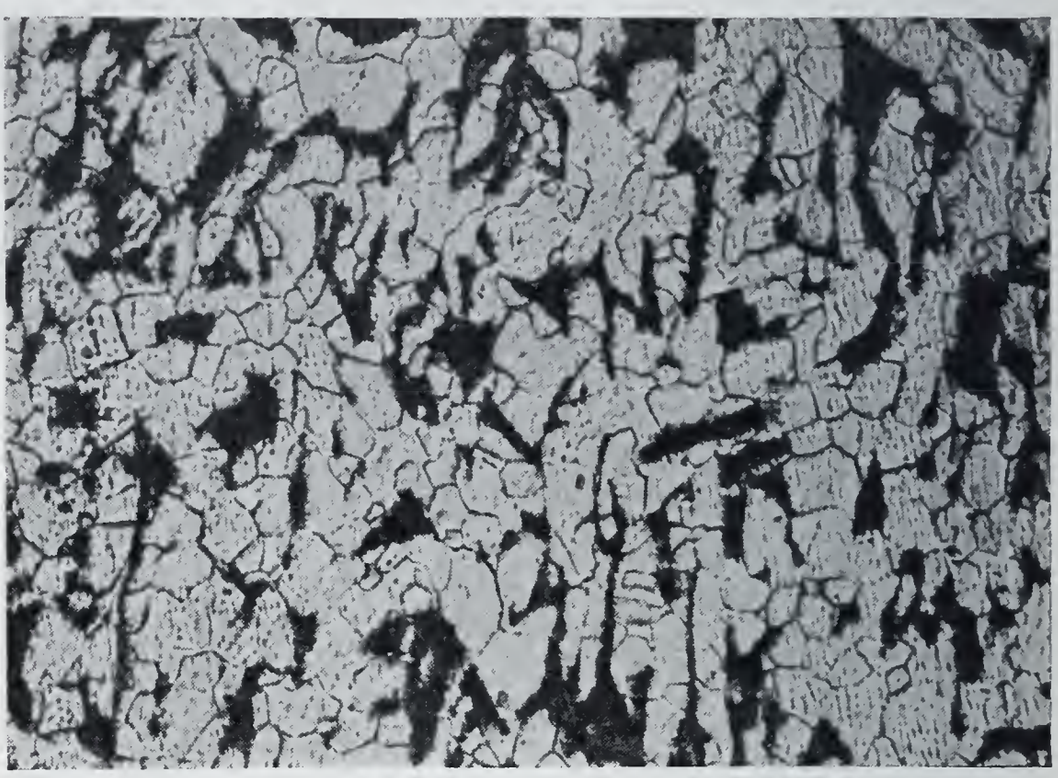

Fig. 34. After 40 Per Cent. Cold Reduction.
Annealed at 600 Degrees C.

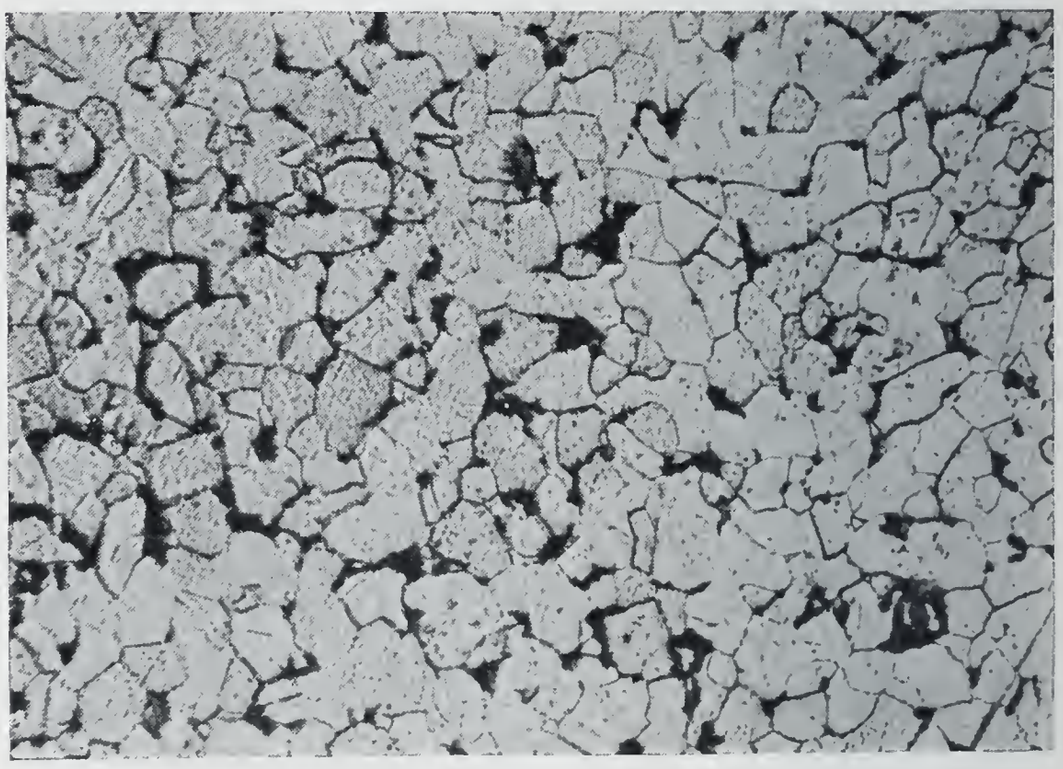

Fig. 35. After 40 Per Cent. Cold Reduction.
Annealed at 800 Degrees C.

change in structure. Both the pearlite and ferrite are strung out in the direction of drawing. Fig. 34 shows the same material again with a 40 per cent. reduction. In addition, it has been given an anneal of 600 degrees C., this temperature being in the recrystallization range. It will be seen that the ferrite has completely recrystallized, while the pearlite has not been affected by this temperature. Fig. 35 shows the same material, again with a 40 per cent. reduction, followed by annealing at 800 degrees C. Not only has recrystallization of the ferrite taken place, but also some growth is evident, as compared with the unusually fine grain size of Fig. 34. This temperature has been sufficiently high to permit rearrangement of the pearlite also, and the structure now presents a uniform and fine-grained appearance, from which all evidence of cold work has been eliminated. Returning now to Fig. 31, it will be remembered that the material in this case has received a 12 per cent. reduction and that the structure is very similar to that of the original hot-rolled structure; the grain size in the hot-rolled material being 0.0022 square millimeters, and in this particular specimen 0.0019 square millimeters. Fig. 36 represents the same material and same reduction, but in this case an anneal of 800 degrees C. has been given. The abnormally large grain size is very noticeable, the average grain size being 0.0192 square millimeters, or 10 times as

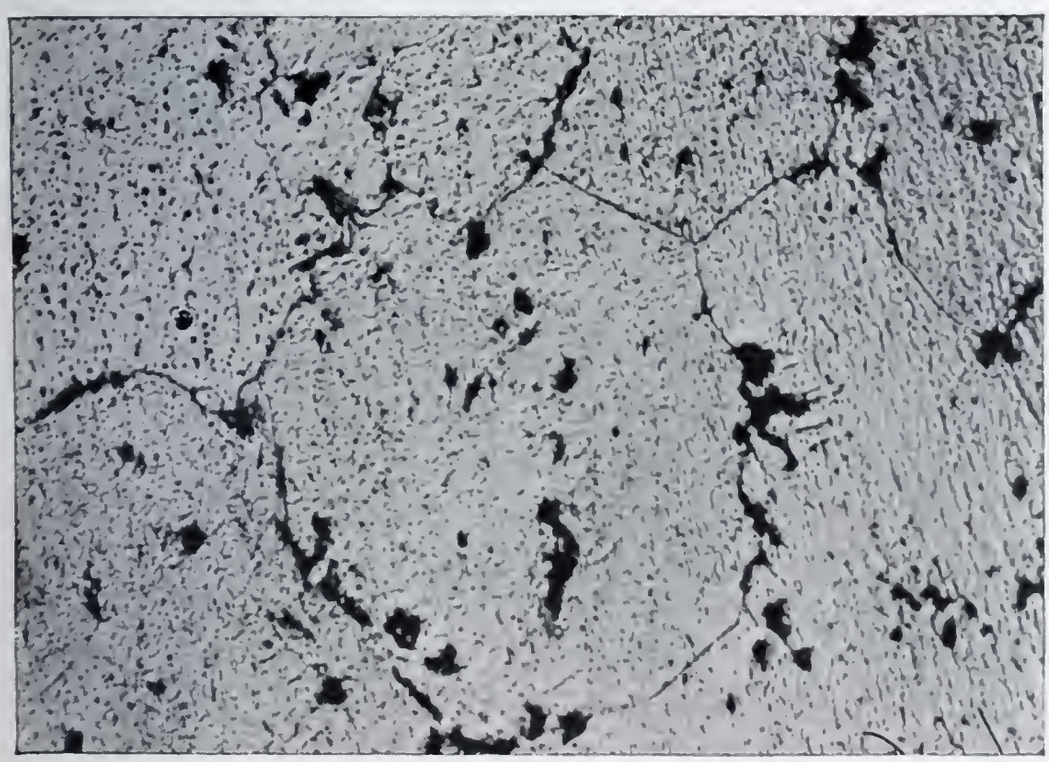

Fig. 36. After 12 Per Cent. Cold Reduction.
Annealed at 800 Degrees C.

great as existed prior to the annealing. With such a grain size, undesirable physical properties are naturally to be expected, and the physical characteristics of material in this condition can best be described as treacherous and uncertain rather than possessing any consistently lower physical properties.

The phenomenon of grain growth resulting from cold straining and annealing has been the subject of many investigations, and it is quite apparent that in the manufacture of cold-drawn seamless tubing ideal possibilities for such grain growth may exist. It becomes necessary, therefore, for the tube maker to understand thoroughly the conditions both of strain and annealing which produce grain growth, and unless selection of grade of steel, percentage of reduction, and annealing temperature are made with a thorough understanding of these conditions, difficulties of a serious nature will be met with, both by the maker and the consumer. Our experience has been such as to confirm the results of most other investigations into this condition. The statement is usually made that this phenomenon is confined almost entirely to very low carbon steels. Our experience is that, while the most pronounced results are found in very low carbon material, evidences of the same tendency are apparent, under the right conditions, in material as high as 0.20 carbon.

There has been a tendency on the part of consumers, in some cases, to limit the manufacturer in the amount of reduction to be given a tube—the limit, of course, being a maximum. Experience indicates, however, that instead of being a safeguard, such limitation may lead to serious difficulties. The results of heavy reductions, at least so far as seamless tubes are concerned, are beneficial. Recrystallization which takes place at the proper temperatures, following heavy reduction, leaves the material in a fine-grained condition and results in very good ductility for corresponding tensile strength. Owing to conditions peculiar to the tube-making industry there is no danger of overdrawing, as the result of heavy reduction, such as is found in the wire industry.

The many steps in the operation of making seamless tubing and the various factors influencing the quality of the finished product offer an unlimited field for investigation and discussion; and it is, therefore, impossible in a limited time to give anything but the most sketchy account of the methods and technical questions involved.

CLASSIFICATION AND APPLICATION OF PYROMETERS*

By R. W. Newcomb†

The paper I have prepared is very elementary. To many of you it will be repetition of what you already know. This is not an apology because I believe it sometimes does us all good to review things that we have known. Frequently in doing so we get a new perspective when looking at something old from a different angle.

I would like to cover some particular applications of instruments, the problems involved and results obtained, but you represent so many different industries that this is hardly feasible. I shall therefore simply cover my subject in a very incomplete and elementary way, hoping that you will later bring out in your discussion points on practical and definite applications. I have four subdivisions to cover:

Types. Classes or types of instruments in common use.

Suitability. Factors governing the suitability of any one of these types for a given set of conditions.

Construction. Points in regard to the construction of instruments that should be understood by those using them.

Serviceability. Factors affecting the serviceability of pyrometers.

Types. The four types of pyrometers in most general use are the thermo-electric, the electric resistance thermometer, the optical pyrometer, and the radiation pyrometer. This paper is devoted mainly to the first two types, as these, in the order mentioned, are most widely used to-day.

I wish to establish clearly the difference between thermo-electric pyrometers and electric resistance thermometers. It will seem strange to many of you that there should be any confusion of the two, but my experience has been that many do not understand exactly what the difference is and, as a result, thermo-couples are often used where electric resistance thermometers would be better.

Fig. 1 shows a simple thermo-electric system. It consists of three essential parts—a thermo-couple, the connecting leads, and the instrument.

The thermo-couple may be any combination of a number of

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†General Manager, Charles Engelhard, Inc., New York.

metals and alloys, most of which are known to you, such as nickel, chromium, iron, constantan, platinum, rhodium, iridium, and alloys of these metals. The connecting leads may be of copper but, in this case, the cold junction of the couple is at its junction to the leads. In case the instrument has cold-end compensation in some form or other, a special alloy lead is used as a connecting means between the thermo-couple and the instrument or compensation box.

Fig. 2 shows a simple electric thermometer system. You will see a very distinct difference between this and the thermo-electric system just shown. In this system the instrument shows the unbalance, or in

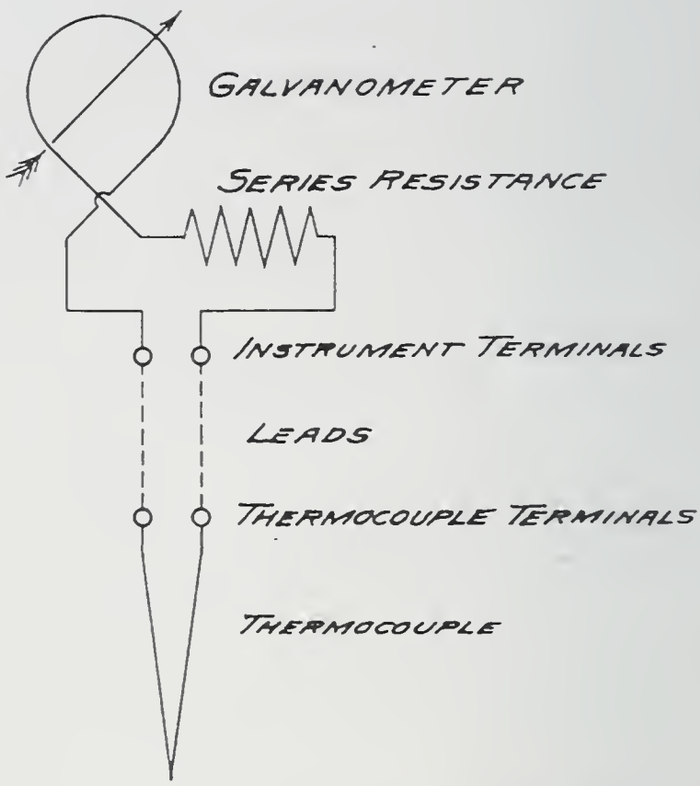

Fig. 1. Simple Thermo-Electric System.

some cases, the balance of a Wheatstone bridge, while in the first case the instrument showed a thermo-electric current generated by the thermo-couple itself. The balance of the Wheatstone bridge which is used on the electric thermometer system depends on the resistance of the thermometer spiral.

The electric thermometer bulb may be composed of any one of several metals which have proved themselves suitable for such service. Copper is sometimes used for very low temperatures, nickel is more frequently used for temperatures up to 300 degrees C. Platinum, and now I mean the very highest grade of chemically pure platinum, is

generally used for thermometer spirals operating at the higher range up to 700 or 750 degrees C.

With electric thermometers, there is no cold-end correction to be made, and therefore the connecting leads between the thermometer and the bridge coil may be of ordinary copper. The instruments, as in the case of the thermo-electric pyrometers, may be either balanced or unbalanced instruments—that is, potentiometer or deflection— and either an indicating or a recording type as preferred.

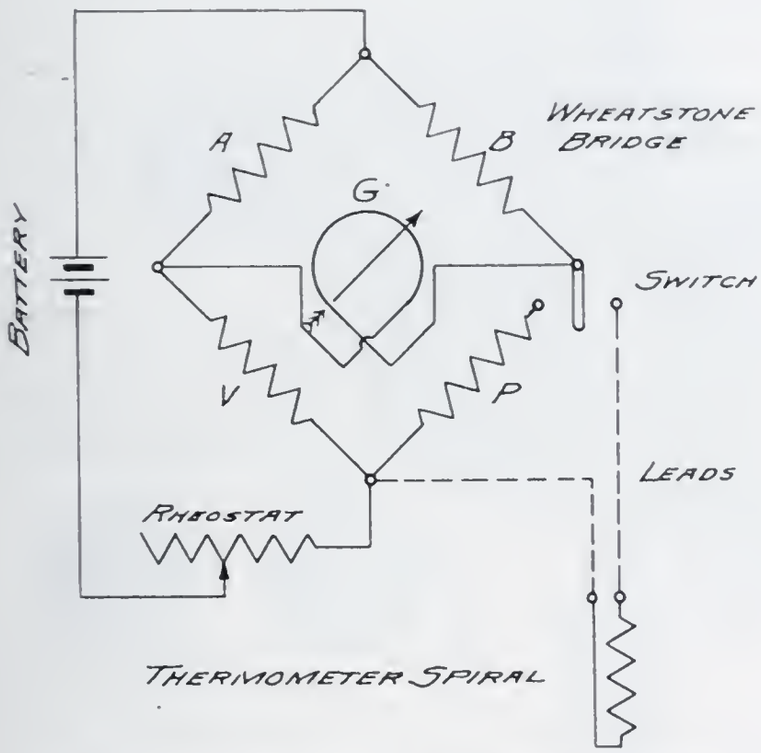

Fig. 2. Simple Electric Thermometer System.

Fig. 3 shows an optical pyrometer in one of its several forms, and is merely illustrative of a type. With this instrument the operator simply matches colors. The filament of a calibrated incandescent bulb heated by current from a battery is so regulated that the temperature of the filament can be varied with a rheostat by increasing or reducing the current from the battery. When the color of the filament exactly matches the color of the background against which it is sighted, the two are presumed to be at the same temperature. In this form of optical pyrometer, the temperature measurements are taken from an ammeter connected in the battery circuit to measure the amount of the current flowing through the heated filament of the bulb. When the bulb is properly calibrated, this current is a measure

of the temperature of the filament. The instrument can therefore be calibrated directly in terms of temperature.

The basic principle of a radiation pyrometer is shown in Fig. 4. By focusing arrangements, the radiant heat from a furnace or heated body on which the instrument is sighted, is concentrated on the hot junction of a small thermo-couple contained in the instrument. The electromotive force set up by the temperature difference between the hot junction and the cold junctions of this couple is measured on an

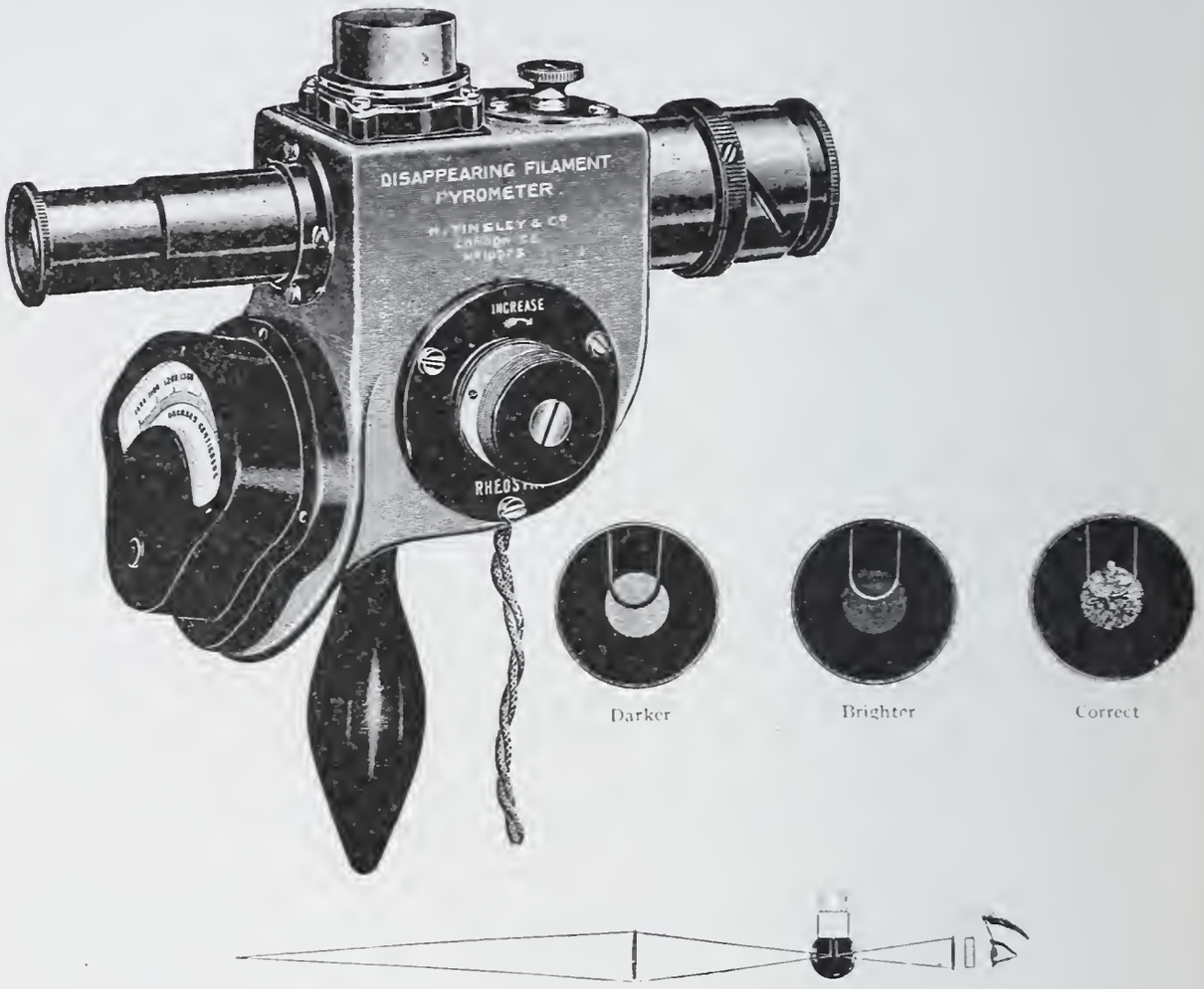

Fig. 3. Optical Pyrometer.

instrument the same as in connection with the thermo-electric system. The leads may be copper or cold-end extension metals.

Suitability. Each of the four systems described above has its own field of usefulness, although they do overlap. The electric thermometer, and the thermo-electric pyrometer, have a common field of usefulness over a certain range. The thermo-electric, and either the optical pyrometer or the radiation pyrometer, also have a common field of usefulness, but for many purposes the lines of demarcation separating the four systems (or rather the three systems, because the optical

and radiation instruments cover almost identically the same field) are quite clear.

The important questions determining which one of these instruments will best serve for a given purpose are as follows:

1. What is the range of temperatures to be measured?
2. What degree of accuracy is required?
3. Is the instrument for portable service or for permanent installation?
4. What degree of sensitivity is required; that is, will there be a time lag, and can a lag be permitted without detriment to the process?
5. Is a record required?
6. Are the instruments required for use with automatic temperature regulators or for some other special application?

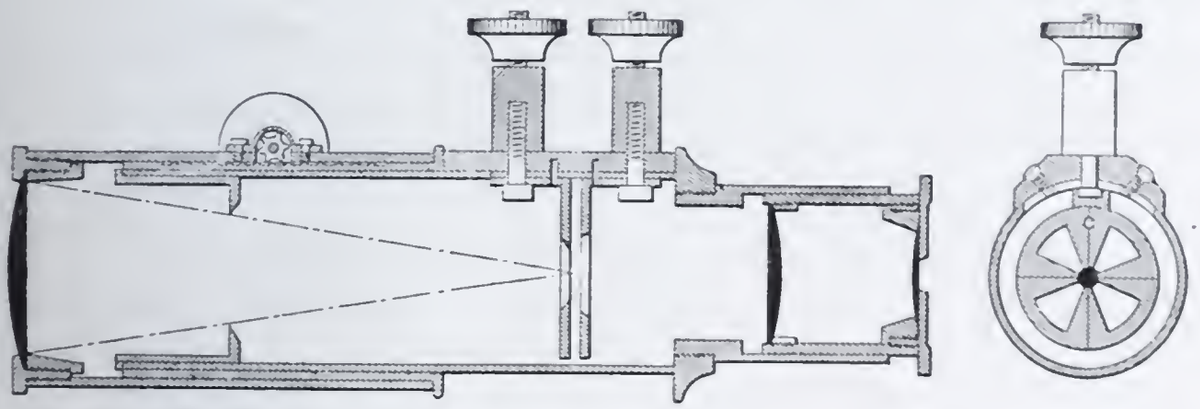

Fig. 4. Féry Telescope Pyrometer (From "Measurement of High Temperatures." By Burgess and Le Chatelier. Ed. 3, 1912, p. 279).

As to range, the instrument which covers the lowest range, with the greatest degree of accuracy and general utility, is the electric thermometer. This instrument can be used from almost absolute zero up to a temperature in some cases as high as 800 or 900 degrees C. This upper range, however, is above the temperature at which most electric resistance thermometers give good service under permanently installed conditions. The electric resistance vs. temperature characteristics of certain metals can be projected either above zero or below zero with nearly the same resistance change per degree. It is for this reason that these instruments can be used at very low temperatures with the same accuracy and satisfaction as at the intermediate or higher temperatures. I know of installations in operation at −185 degrees C. in measuring temperatures of liquid-air apparatus. From

this point on up through refrigeration temperatures, heating and ventilation temperatures, measurements of humidity, power-plant temperatures (such as superheated steam, condensing water, flues, etc.) on up to 750 degrees C. and perhaps a little higher, electric thermometers are to be recommended.

The thermo-electric system is also sometimes used for rather low temperatures but when the temperature of the hot junction, or what is normally the hot junction, is lower than the temperature of what is normally the cold junction, the polarity of the themo-couple reverses. There are a number of successful installations of thermo-couples operating at very low temperatures. Generally speaking, however, thermo-couples are inferior to electric thermometers for high accuracy at low temperatures.

The upper practical range for the thermo-electric system is in the vicinity of 1500 degrees C. The serviceability at these high temperatures depends to a very large extent on the thermo-couple mounting; that is, on the kind of protection tubes that are used.

Optical and radiation pyrometers are occasionally, but not frequently, used at temperatures below 1200 degrees C. I think you will agree with me, however, that their principal field of usefulness is at the higher temperatures, above the range where the thermo-electric system gives good service. Their upper range of temperatures you might say is almost unlimited, because, by using proper screens, they can be calibrated for an extremely high range the extent of which I will not attempt to limit.

When we come down to the factor of accuracy required, we get to a more acute subject. I do not expect to be challenged when I say that on this score the electric resistance thermometer is far superior to the other three systems. Resistance thermometer spirals can be so well made that they possess a higher degree of interchangeability among themselves than do thermo-couples or optical and radiation pyrometers. When operated over a very small temperature range, it is possible to use instruments considerably less sensitive than required with any of the other instruments because by selecting the proper bridge-coil values and voltage value across the bridge, the voltage drop which the instrument really measures can be brought up to a point where even a rather crude instrument will give a reasonably high degree of accuracy. In other words, the electromotive force available to operate the instru-

ment per degree change in temperature, can be made very much higher than on any of the other three systems.

Another point which increases the accuracy of the resistance thermometer, is that the instrument can be calibrated to cover the exact operating range, without resorting to mechanically suppressed zeros. This is possible because there is no cold-end error and by proper selection of the bridge-coil values the instrument does not have to be calibrated with a suppressed zero, when starting the scale at a temperature above atmospheric temperature. For example, it is as easy to calibrate an electric thermometer with a scale range from 600 to 700 degrees C. as it is to calibrate one with a scale range from zero to 100 degrees, and it will deliver almost as high a degree of accuracy at the higher as at the lower range. Inasmuch as the electric resistance thermometer has no cold-end error, there is no danger of inaccuracies creeping in on account of faulty cold-end compensators or extension leads with poor insulation. It is unnecessary to use special alloy compensating leads, and here, therefore, the thermometers gain in accuracy, because it is as difficult to control the temperature electromotive force characteristics of cold-end leads as it is to control the temperature electromotive force characteristics of various thermo-couples.

There is still another point in favor of the electric resistance thermometers over the other systems so far as their accuracy is concerned. This particularly applies to the systems which operate on the unbalanced Wheatstone bridge principle. It is necessary to explain in some detail just what this point is in order that it shall be clear.

We all know that even with the best of instruments things sometimes happen to them that effect their calibration. In the case of the electric thermometer operating on the unbalanced Wheatstone bridge system, however, the errors which are most liable to occur are automatically compensated.

Referring again to Fig. 2, the coil P has an electrical resistance exactly equal to the resistance which the electric thermometer bulb has at the highest temperature for which the scale of the instrument is calibrated, with an additional resistance equal to the resistance of the leads to the thermometer for which the set is calibrated. By the switch shown, either the thermometer spiral or this resistance coil P can be connected to one side of the bridge. When coil P is connected in circuit, the pointer of the instrument should deflect to the highest

scale division on the instrument. This is marked with a red line and when the pointer stands exactly on the red line, it shows that the battery voltage is correct. If it does not stand on the red line, then the battery voltage is adjusted by regulating the rheostat until it does.

From this you will see that the instrument is made to read correctly whenever the battery voltage is adjusted. If the instrument itself has changed calibration somewhat, due to any one of several causes, these are automatically compensated by applying a higher or lower battery voltage. This is a feature of much importance and one which is frequently overlooked in connection with this system of electric thermometers.

Of the other three systems—thermo-electric, optical or radiation —you will agree with me that for most purposes within its range, under ordinary conditions, the thermo-electric system will deliver a higher degree of accuracy than the other two. As to optical and radiation instruments, there will be some controversy as to which of the two is the more accurate. I want to avoid controversies and therefore will leave that question to you. Excellent information on this question can be obtained in "Burgess and Le Chatelier."*

From the standpoint of portability, undoubtedly the thermo-electric system has an advantage over the other three, although it may be closely followed by the electric thermometer and the optical pyrometer. Most forms of radiation pyrometers are less readily portable than the other three.

As to sensitivity, undoubtedly the optical pyrometers lead in this characteristic. The response is as rapid as the speed of light (186,000 miles per second) which is fast enough for anyone. If, however, we include the time actually required to match the color of the filament against the background then the sensitivity depends on the skill of the operator, and neither you nor I would attempt to make an estimate of this factor.

The sensitivity of a good radiation pyrometer should come next. I emphasize the adjective *good* because it depends strictly on this. The little thermo-couple which is the active element of this instrument has a very small junction and its response to the heat radiated and focused on it should be very rapid.

*Measurement of High Temperatures. By G. K. Burgess and H. Le Chatelier. Ed. 3, 1912. Wiley. New York.

Between the thermo-electric and the electric resistance thermometer systems there is not so very much difference in sensitivity and, with these two, this factor depends entirely on the constructuion of the hot end. Their sensitivity depends on the diameter of the wire from which they are made and especially upon the tubes in which they are mounted. It is needless to say that the smaller the mass at the end of either the thermometer or the thermo-couple, the more quickly will this part respond to changes in temperature.

There is another factor entering in here which I would like to mention, and that is radiation. Few of us appreciate the very important part that radiation may play on the temperatures indicated by either a thermometer or a thermo-couple. I have in mind one case where electric thermometers were used in taking temperatures on a boiler under test. It was found that when a very sensitive platinum and quartz thermometer was mounted in a ⅜-inch, perforated, drawn-steel tube, it read too low by nearly 380 degrees when inserted between boiler tubes spaced approximately two inches apart. This error developed when measuring gas temperatures at about 800 degrees C. Special baffle-plates were built on this thermometer to prevent radiation to the cold tube surface, and this correction increased the temperature as indicated by the thermometer to the extent named above; and I presume that there was still a large percentage of heat lost by radiation to the somewhat colder baffle-plates, the temperature of which was affected to a certain extent by the cooler tube surfaces.

Any of you who are interested in the effect of radiation on temperature measurement (and again I say it is a very important factor) should secure United States Bureau of Mines Bulletin 145.*

It is difficult to say just when the sensitivity of the couple should be high and when it should be low in order to give the best results in service. This is particularly true on furnaces where automatic temperature regulation is wanted. One would think that the best regulation would be obtained when using a thermo-couple of the highest sensitivity. In practice, however, this is not verified, because the thermo-couple may be subjected to draft currents caused by opening doors, or to stratification of gases, so that the regulator keeps "hunting" all the time. Under such conditions, it is far better to use a

*Measuring the Temperature of Gases in Boiler Settings. By Henry Kreisinger and J. F. Barkley. Government Printing Office, Washington, D. C. 1918.

thermo-couple of lower sensitivity. Another factor affecting the sensitivity of a thermo-couple or thermometer is the inside projection. It is seldom safe to have an inside projection of less than six inches, otherwise the temperature of the thermo-couple or thermometer may be greatly affected by the temperature of the furnace wall. This point is of greater importance when the protecting tubes are metal, than when they are porcelain or some other refractory material with low thermal conductivity.

Construction. When sufficient care is taken in purifying and alloying the metals used, the thermo-couples have a high degree of interchangeability and maintain their calibration over long periods. Their life is therefore longer than where use is made of impure metals or metals improperly alloyed. Improperly manufactured thermo-elements not only lack interchangeability from couple to couple, or from batch of couples to batch of couples, but the readings they give will largely depend on the temperature gradient which is established in service along their length. I shall cover this last point in a little more detail further along in my paper.

There is one particular point in regard to thermo-element wire and protecting tubes and contamination that I think is generally misunderstood. One frequently hears it said that rare-metal thermo-couples are too easily contaminated to be used for this or that purpose. We all know that platinum is one of the most stable metals known to science. It is least chemically active and least affected by most outside conditions. A rare-metal thermo-couple therefore should be —and according to my experience is—the hardest of all thermo-couples to contaminate. The reason such care is used in protecting them is not because they are more susceptible to contamination than other types of thermo-couples but because a higher degree of accuracy is expected from them, and contamination which would be unnoticed on other types of thermo-couple might be of serious disadvantage on the rare-metal type.

Most people fully understand that a rare-metal couple requires a porcelain protecting tube to give the best service. Too often, however, they insulate the platinum wire inside of this porcelain tube with ordinary fire-clay insulators. Of what advantage is it to protect the platinum wires against possible external contamination, when using insulators which are high in contaminating agents? If you are

going to protect the thermo-couple it must be protected from beginning to end and not at one point only.

Aside from the element wires themselves, the main thing, of course, is to get a thermo-couple mounting—that is, protecting tubes, and other fittings—which adapts the couple to the service for which it is intended. It is my experience that the users of pyrometers do not fully realize the importance of this matter of thermo-couple mountings. We too often find iron-constantan thermo-couples protected in nickel-chromium alloy tubes; or chromel couples protected in iron tubes; or platinum couples in metal tubes without other protection. Under conditions such as these the protecting tubes themselves may be a source of contamination. The mounting of the thermo-element wires must not only suit the wires themselves but must also be selected to fit the conditions under which the couple will be used. Some protection tubes give longer service under oxidizing conditions in the furnace, but others will give longer service when the conditions are reducing. Some tubes bloat badly when subjected to sulphur fumes, and tubes which would give good service in ordinary gas-fired furnaces when subjected to products of combustion only, would fail utterly if used in a lead-bath or in a cyanide pot.

There is a wide difference in the suitability of different electric thermometer bulbs, depending on the metals from which they are made and how they are constructed. These instruments can be made to give an unusually high degree of accuracy—perhaps higher than that given by any other means of measuring temperature suitable for either scientific or industrial purposes. The finest example of the electric thermometer is perhaps that which is used for calorimeter work. Instruments frequently furnished for this purpose, will indicate temperature differences to the order of 0.001 of one degree C. Needless to say, this type of thermometer is not suitable for industrial purposes. I call your attention also to the fact that when I say that this thermometer is capable of measuring temperature *differences* to the order of 0.001 of one degree, I do not mean that it will measure absolute temperature to this accuracy. There are in service, however, electric thermometer bulbs and measuring systems which, day in and day out, are giving accuracy to the order of 0.1 of one degree C.

The main points to look out for, as far as the serviceability and accuracy of thermometer bulbs are concerned, are the following:

1. The resistance metal must be one whose temperature vs. electrical resistance characteristics will not change over the temperature range to be covered; also one which will resist corrosion under any conditions to which it may be subjected in service.

2. The active element must be so supported and protected that it cannot deform or become strained, and especially so that moisture cannot affect it.

Copper is sometimes used in thermometers for low temperatures; that is, up to 100 or 200 degrees C. Nickel is used more frequently than copper. Nickel has an upper range which is placed at about 300 degrees C. It could be used at a higher range, except for the fact that at about this point it passes through a critical temperature somewhat similar to the critical point of iron with carbon content. For the higher temperatures, platinum spirals are almost universally used, and these are available for continuous service up to 700–800 degrees C. The accuracy of the thermometer spirals depends on how well the original resistance of the spiral is maintained. To maintain it, there must be no corrosion; there must be no leakage of current due to moisture; there must be no galvanic battery action; the metals must be free from critical ranges or transformations; and they must be so mounted that there will be no strain, or any other influence that will in any way whatsoever affect their original resistance or their change in resistance with change in temperature. I have known regular manufacturers to sell thermometers made from copper wire with enamel and silk insulation wound on wood. Between this and thermometers with platinum spirals mounted in quartz there are a number of others all of which have certain fields of useful application.

Aside from the factors affecting the permanence of the thermometer spiral, there is one other factor of importance—the desirability of a thermometer with the largest resistance change per degree of temperature change. The instruments used therewith are called upon to respond to a greater electro-motive force per degree of temperature change, and the effect of a variable line resistance is of smaller magnitude on such a thermometer than on one having a low resistance change per degree.

As to factors of importance in the construction of instruments; when a pyrometer salesman comes to you, you hear a lot about moving coils, and springs, and windings, and pointers and all of this.

Fig. 5 shows five of the most common types of moving systems now used in pyrometers.

A is used when the scale is mounted in a vertical plane, with the axis of the moving coil perpendicular thereto. This kind of coil construction was the one most generally used when pyrometers were first developed. Instruments of high sensitivity are not made in this way, because the bearing surface on the pivots is on the sides rather than on the point. This materially increases pivot friction. There is also

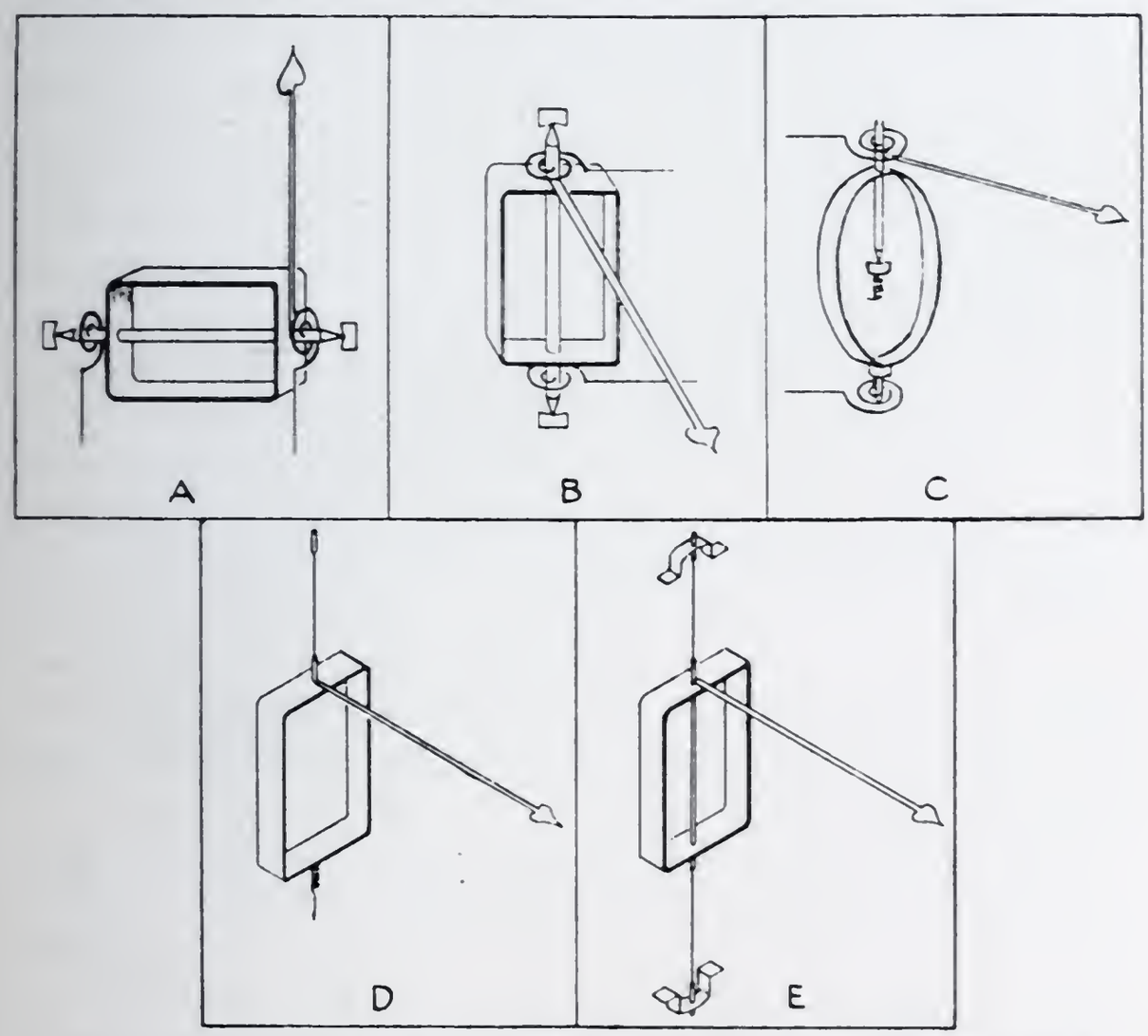

Fig. 5. Five Common Types of Moving Systems Used in Pyrometers.

trouble from this kind of moving coil because it has to be very delicately balanced. Recorders with round charts are almost invariably equipped with this style of moving system.

B shows a pivoted type of moving coil, with the axis of the coil vertical. The scale used with such a coil may be either a horizontal arc (as in the case of a portable indicator) or an edgewise vertical scale (as in the case of a wall type indicator). Many of the objections

to the coil described above are eliminated with this coil. Balancing is less delicate and friction is materially less, because the weight of the coil is carried on the point of the lower pivot. The top pivot serves only as a stabilizer.

The coil marked *C* is a modification of that marked *B* and is used under exactly the same conditions. The difference here is that friction which might be caused by the top pivot is eliminated, but this coil lacks the stability which is possessed by the double-pivoted coil.

D shows a type of moving coil which has proved to be very accurate, but its fault is a lack of ruggedness and the necessity for leveling the instrument in which it is used. With this coil, friction is entirely eliminated, because it is hung from a thin metallic ribbon. The coil at the bottom exerts practically no influence on the movement of the coil and serves only as an electrical connection. Instruments of this type can be made with a very high electrical resistance and there is no wearing out of such a moving coil because there is no friction.

The coil marked *E* is a modification of the one marked *A*. In this case the coil is not freely hung but is held in tension between two metallic ribbons, one at each end of the coil. This retains the sensitivity of the single suspended instrument and overcomes the fault of delicacy and the necessity for leveling.

There are two general types of instruments used with thermocouples and thermometers. One type is known as the deflection system; the other, as the balanced system. Both have their advantages and their fields of usefuleness.

The potentiometer is a balanced system in which the electromotive force developed by the thermo-couple is offset—or "bucked", as we call it—by counter electromotive force set up from a battery circuit in connection with the instrument. This balance of one against the other is obtained either by manual operation (in the case of indicators) or by automatic operation (in the case of recorders). This instrument depends for its accuracy on the constancy of a standard cell and the constancy of some critical resistances within the instrument; as well as on the ability of the galvanometer to balance correctly at zero when no electromotive force difference is applied across this terminal, and on the mechanical ability of the instrument to move its recording stylus correctly as called for by the movements of the galvanometer itself.

The direct-deflection instrument actually measures the electromotive force of the thermo-couple by a motor effect. By motor effect, I mean that the moving coil of the galvanometer corresponds to the armature of the motor, and the permanent magnet in the instrument corresponds to the field coils of the motor. The movement of the armature or coil is restricted by the tension of the coil spring or ribbon against which the moving coil operates. The magnets of the instrument establish a permanent field and are not affected by the electromotive force from the thermo-couple. The moving coil alone is under the influence of the current from the thermo-couple. The lines of force set up by the current through the moving coil are at an angle to the lines of force produced by the permanent magnet. These two separate sets of lines tend to become parallel and, in doing this, turn the moving coil into a certain position depending on the strength of current. The current flowing depends directly on the electromotive force of the thermo-couple and on the resistance in the circuit. Sensitive instruments of this type are capable of responding to almost infinitesimal changes in current.

As an illustration of the extremely small forces to which a high-grade pyrometer instrument must respond, the following example is taken:

It requires 8.223 foot-pounds of energy to convert a drop of water 1/16 inch square on each side into steam at 200.3 pounds gage pressure, from a temperature of 32 degrees F. If my mathematics is correct, this is equivalent to 0.106 B.t.u. and one B.t.u. = 1054.2 joules. From this it follows that it requires 11.17 joules to convert the drop of water into steam. One joule is equivalent to one watt-second.

Pyrometer instruments of the double-suspended type are capable of full-scale deflection on a power equivalent to 0.000000450 watt. Converting these figures, it is shown that the power required to hold the pyrometer deflected full scale for 288 days is just enough to evaporate one drop of water under the conditions cited.

You require a pyrometer instrument to respond to changes in power equivalent to not less than 1/150 of this full-scale value. Therefore, the change in power, to which the instrument is called upon to respond, is equivalent to evaporating the drop of water in 120 years.

You frequently hear the term "high resistance" in connection with deflection pyrometers. This term in itself means absolutely nothing, because what is high resistance to you may not be high resistance to me. Most of you understand the importance of high resistance, so called, in this type of instrument. I would like to spend a minute or two with an example on this point.

If a thermo-couple develops an electromotive force at its terminal, let us say of 10 millivolts, then this 10 millivolts creates a current in the circuit connected to the terminals of the thermo-couple, and the amount of current is directly proportional to the amount of resistance in the circuit. If the external circuit consists of a plain wire 10 feet long, and if we neglect the resistance of the thermo-couple itself, then there would be one millivolt electromotive force drop along this wire for each foot of length. In other words, the 10 millivolts would be equally divided into 10 parts along the wire, each millivolt corresponding to one foot of wire. If instead of taking a 10-foot wire for our illustration we use an instrument and one foot of this same wire, then if the instrument has a resistance of nine ohms and if the resistance of the one foot of wire is one ohm, the instrument will show an electromotive force of nine millivolts while the other one millivolt is lost in the one foot of connecting leads whose resistance is 0.1 the total resistance of the circuit. Therefore, if we have a pyrometer instrument with a total resistance of nine ohms, and if we have external leads with a total resistance of one ohm irrespective of their length, then our indicator is going to read 10 per cent. too low because 0.1 of the total electromotive force is lost in the leads. If the resistance of our indicator is 99 ohms, we lose one per cent. If it is 1000 ohms, we lose 0.1 of one per cent.

Good deflection instruments to-day, for the most part, have a resistance ranging from 200 to 1000 ohms. The resistance of the instrument is a measure of its sensitivity when considered together with the total angular deflection of the pointer. I say *angular deflection,* rather than simply *deflection* because with the same angle of deflection a wider scale is possible with a long pointer than with a short one. The objection to the long pointer is that instruments with long, heavy pointers are inclined to be sluggish in their action in responding to temperature changes, but at the same time are inclined to overswing. In other words, they are not critically damped. Fur-

thermore, if the pointer is too long, the instrument will be affected by vibration to a greater extent than are instruments having shorter pointers.

The accuracy of deflection instruments depends on the permanence of their magnets, the constancy of their control springs, and the constancy of the resistance of the moving coil and of the so-called swamping resistance.

Cold-end compensation is another point of much importance in a pyrometer system. Several of the instruments have what is called automatic, internal, cold-end compensation. Others require an adjustment of the pointer to a position on the scale which eliminates any calculations so far as cold-end temperature is concerned. On any of these it is necessary that the cold end of the thermo-couple be brought to a point of constant temperature or to the instrument itself where the automatic compensation is made. Whether internal, automatic compensation is more accurate than the external, constant-temperature type is a question not yet fully answered.

With instruments having internal automatic compensation long extension leads to the couple are usually required, and these cost considerably more than ordinary copper leads. In other words, as it is necessary to bring the cold junction of the thermo-couple to the instrument itself, the extension leads must run the entire distance. With the other system it is necessary only to run the extension leads to a point of constant and known temperature. In some cases the cold junction—that is, the junction between the extension leads and the copper leads—is buried in the ground; in other cases it is carried to a junction box filled with "sil-o-cel" or some other insulating material, but more frequently to small, so-called, unit type, cold-junction boxes the temperature of which is maintained thermostatically within a degree or so of a constant value.

Any of these types of cold-end correction or compensation is undoubtedly accurate enough for almost any industrial application. For scientific purposes, special forms of cold-junction apparatus have been developed, and these can be relied upon to even a greater extent.

Serviceability. What you are all primarily interested in is, not how an instrument is made, but what certain instruments will do for you under certain conditions.

About the only way that information of this kind can be obtained is through the school of experience. Experience has taught us that certain types of thermo-couples give best service under certain conditions. For example, a base-metal thermo-couple of the iron-constantan type gives best service when used under reducing conditions; that is, with an excess of CO.

Experience shows that chromel-alumel thermo-couples give best service under oxidizing conditions, and that for this type of thermo-couple the worst situation is one where conditions are alternately reducing and oxidizing.

Experience has taught us that silica is a very serious contaminating agent for rare-metal thermo-couples, and that the use of optical or radiation pyrometers in such work as on glass tanks is difficult on account of the transparency of the batch, and because of the reflected temperatures throughout the tank.

Experience has taught us that a thermo-couple which has become contaminated cannot be satisfactorily checked in the laboratory or anywhere else except in the very position where it is being used.

Through experience we have learned that there are certain kinds of protecting tubes that give the best protection to various types of thermo-couples under a given set of conditions; but that, if either the tube or the thermo-couple be changed, failure may result.

Besides getting life from your thermo-couples you are primarily interested in getting results, and to get results you must not only have life but you must also have accuracy. This, too, ties up with the kind of thermo-couple used and with its protection, and it also ties up with the location of the thermo-couple, its inside projection, and many other factors which depend on the kind of fuel used, the design of the furnace, the work being done, etc. No fixed rules can be applied in any one case. It is a question of experimenting to find the right combination of thermo-couple and protecting tube for a given set of conditions.

If you have not had experience yourself to show what is the right combination it is the proper thing to go to someone who has had that experience. Observation on your part will show that pyrometer manufacturers get gray-haired early in life. This comes to them in obtaining experience.

Practically all of my paper has been confined to elemental things relating to pyrometers. It is in discussion, however, that the practical end of this question can best be covered and I hope that you will ask questions or tell us of your own experiences to bring out points which I am sure will be of more interest than the elementary discussion of the subject which I have presented.

DISCUSSION

Mr. F. M. Van Deventer, *Chairman*:* The speaker has said that some of his remarks would be more or less elementary and in the nature of a review to some of us. I am reminded of Thomas A. Edison's remark when asked for his opinion of Elbert Hubbard. He said, "Elbert Hubbard told me many things I already knew, but I didn't know I knew them until he told me". Similarly, in engineering, a review of the facts that we already know brings out new facts and fixes old ones in our minds, so that they will be available when needed in our work.

The subject is now before you for general discussion, and while it is not our custom to call upon members or visitors, there is one man here to-night who has had considerable experience in the design and operation of continuous kilns, and the application of heat to various annealing and similar operations. I refer to Mr. Philip Dressler and invite any comments he may care to make on the general subject of pyrometry in heating operations.

Mr. Philip Dressler:† You have taken me at a disadvantage in requesting me to discuss this paper without giving me an opportunity to prepare for it but it will be a pleasure to recount to you some of my experiences in using this type of equipment.

I believe that my company was one of the very first to use pyrometers on a large scale in the ceramic industry. From the very first we equipped our tunnel kilns with complete sets of instruments giving the temperature from end to end. Like everybody else we had a number of sad experiences from using wrong types of protecting tubes, wrong types of couples, and incomplete systems.

In order to get the best results it is absolutely essential to make a study of all the details of a pyrometer system. Good couples are necessary, the wiring installation must be properly made, and you must have a good instrument. Without all of these, good results can not be expected. Many a pyrometer installation is practically ineffective on account of no provision being made for cold-junction correction. In many cases this introduces an error of 50 to 100 de-

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†American Dressler Tunnel Kilns, Inc., Cleveland.

grees in the reading, varying according to the time of year. In many cases, systems are entirely inoperative owing to the fact that the users do not keep the calibration of the couples reasonably constant.

I have run across systems where thermo-couples were reading at least 100 degrees out, due to contamination. A pyrometer system is not a piece of equipment which can be installed and forgotten. It requires a certain amount of attention to get the best results. In many of those cases where users say pyrometers are not a good investment, it is largely because they have not given them a fair chance to be successful. They have not installed them correctly in the first place; secondly, they have not maintained them so they can get constant results; and thirdly, they have not studied the results they have obtained.

Probably the most interesting development in the pyrometer business to-day is that of automatic temperature control. This has only quite recently come to the fore but it is becoming more and more important as we have to dispense with the services of experts and attempt to use less skilled labor to control our operations.

There are two general types of automatic control: (1) that in which the heating fuel or current is continuously controlled up and down as required; and (2) that in which only a portion of the fuel or current is turned on and off as the temperature falls below or rises above a predetermined range. The latter is generally the easier type of installation, since the former has to contend with serious lags. To overcome these difficulties the pyrometer manufacturers have been called upon to exercise their highest ingenuity. In the case of tunnel kilns with which I am familiar the lag between the flame temperature and the kiln temperature may amount to as much as from 15 minutes to one hour. That is to say, when the fuel is increased to compensate for reduction in temperature in the kiln it may be an hour before the final results of the increase have had their effect on the kiln temperature. This lag makes the automatic control extremely difficult. A method has to be found whereby the adjustment can be prevented from going too far while the kiln is building up its temperature. This and other similar problems are probably the most interesting department of pyrometry to-day.

I think perhaps Mr. Newcomb is a little hard on the optical type of pyrometer. In my experience in ceramic kilns where fairly good

black-body conditions exist, the optical pyrometer checks quite well with the thermo-couple. In our own laboratory when we are running high-temperature experiments above the point where a platinum thermo-couple begins to deteriorate rapidly, we habitually withdraw the thermo-couple from the furnace at about 2500 degrees and continue the readings with the optical pyrometer. Before withdrawing the thermo-couple, however, we take a reading upon the extreme end of the protecting tube with the optical instrument and as a rule it checks within 10 degrees of the temperature indicated by the thermo-couple.

Mr. F. M. Van Deventer, *Chairman*: Automatic control of heating operations has been mentioned. I have observed automatic control for maintaining power-station heat balance and believe that a brief description of this method will be interesting. At one particular plant at which the automatic control mechanism attracted my attention, a water temperature of 160 degrees is desired at entrance to the economizer, and the heat balance is obtained by driving the condenser circulating-water pumps by a motor and a turbine connected to the same pump shaft, and distributing the pump load between these two units. When the water temperature tends to fall, the automatic device transfers a portion of the pump load from the motor to the turbine, thereby increasing the quantity of steam entering the feed-water heater. Similarly, if the feed-water temperature tends to increase, the automatic device transfers a portion of the pump load from the turbine to the motor, thereby decreasing the quantity of exhaust steam entering the heater. A recording chart indicates the temperature of the water at all times and a chart which I saw indicated that the temperature did not vary more than a few degrees.

The automatic mechanism consists of a Wheatstone bridge with a resistance thermometer inserted in the heater as one quadrant of the bridge. A variation in temperature unbalances the galvanometer and causes a contact to be made which operates the turbine governor. The set-up is very interesting to watch, as it is almost uncanny to see the mechanism catch a slight variation in temperature and make the proper correction more quickly and accurately than could be done by manual control.

Mr. W. J. Merten:* I should like to ask the speaker's recommendations regarding a type of pyrometer for checking of melting and pouring temperatures of brasses and bronzes. The brass foundry and, in general, the non-ferrous-metal industry is an industry in which the determination of proper temperatures for the different steps in the processes is almost entirely left to the judgment of the operator or to the skill of experienced hands, and it certainly seems that concerted effort towards relief in this line of work would find a very fertile field.

Mr. R. W. Newcomb: As far as I know that is one of the most unsatisfactory departments of pyrometry. For nonferrous metal melting many are using bare base-metal wires plunged into the metal, and that is simply because there is nothing less expensive or much better. That is not good practice, as we all know. We know that where the couple enters the metal at the surface of the metal, the base-metal wire is subject to extreme contamination, and that the accuracy of the couple depends on the temperature gradient along the couple, therefore, unless your couple is at exactly the same depth every time you have a different temperature gradient, you have some trouble using the couple.

Dr. Mathewson, of Yale, designed a thermo-couple that gives good service in low-temperature brass. He used a platinum wire about 0.008 inch in diameter with a small bead, protected by very thin quartz tubes, 1/8-inch in outside diameter, and encased in 1/8-inch iron tubes. I have a statement from him that these thermo-couples can be used to take from 30 to 50 readings without renewing the iron tubes, but he says they are not suitable for cupro-brasses. In regard to protecting tubes for aluminum he suggested that the best tube he had found was an iron tube coated with graphite coating.

Mr. Dressler brought up the question of automatic control. I was not going to go into that. It is too big a subject. But there is one thing I would like to say. In the majority of control jobs one almost invariably gets a record which is a beautiful curve. But really your curve is a measure of the sensitiveness of your thermo-couple.

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With almost any control system, whether it controls 100 per cent. of your fuel or 10 per cent., your thermo-couple goes up in temperature when you are increasing the fuel and goes down when you cut the fuel down. If your instrument is a good one, as soon as it goes below the dividing line (control point) you are going to get more gas, then the temperature goes up until the pointer is above the line, then it goes down again, and so on, therefore you will get a record that shows the sensitivity of the thermo-couple but in most cases not a true record of actual temperature.

Mr. W. J. Merten: I would like to ask another question, pertaining to checking of pyrometers with a calorimeter type of pyrometer, and its use in emergency cases when repairs to the other more costly type are required and its use must be discontinued for some time. A small plant with probably only one instrument is certainly up against it when this one tool is thrown out of service and it has no means of checking temperatures. No matter how crude the means may be, it is an aid to the eye and certainly would be welcomed in a small plant. I have reference to the Siemens pyrometer, which instrument is distributed by your firm. This type of pyrometer has helped me out of a hole many times and I would appreciate your comments in detail on this calorimeter type of heat-measuring instrument.

Mr. R. W. Newcomb: If you have an electric resistance pyrometer instead of a thermo-couple your problem of change is very much more simple. A thermo-couple is not easy to check. The only way to check a couple that has been in service is to check it under the very conditions under which you are using it, and just as soon as you change those conditions, or put it in your laboratory and check it to find out whether it is right or wrong, you will not know how much it is wrong under the service conditions. If it is an electric thermometer and you are using it at 700 degrees C. you do not have to check it at that temperature because the characteristics of an electric thermometer are such that you can project its curve either above or below without a great deal of difference. If you have an electric thermometer to check, measure its electrical resistance when immersed in an ice bath and again in a steam bath. There you have two positive points and if it is right on these you can be reasonably sure that it is right at the

other points. With a thermo-couple you have an entirely different problem. A Siemens water pyrometer is a good instrument to use for such tests. Your idea is that by setting the cylinder on the end of a thermo-couple in use you can get a fairly good check in that way, which I think is so; but to check a pyrometer which you are using in molten metals, you have a pretty difficult job. The way we check a thermo-couple is to take a good piece of the same kind of wire you are using in your couple—one that has never been used and that we know is right—and heat the junction formed by crossing the wire with the standard. If we get no deflection anywhere along the wire we know that the wire we are testing is the same as our standard. If we do get a deflection we know there is a difference in the wire. In that way we can select the point in the length of wire which is contaminated, cut out that length and put in another length of good wire. The reason why it is difficult to test the thermo-couple as a unit is because we can not duplicate the temperature gradient which prevails under furnace conditions. Where you have a zone of equal temperature, the material in your thermo-couple does not make any difference; it is only where you have a temperature gradient. If the wires have not been contaminated and are in good condition, the temperature gradient does not make any difference. But if there is contamination, or if the alloy is not homogeneous, the temperature gradient is the important thing. Unless you can duplicate the gradient, you will not get the same readings when you check the couple.

I do not know whether anyone here has enameling furnaces. At a big plant in the East, making agate ware, they put thermo-couples into one end of their furnace. They had refractory porcelain tubes on platinum couples. The outside ends of those couples were inserted through an iron tube considerably larger than the protecting tube itself. Inside the furnace they had a positive pressure, as is usually the case. I think these were coal-fired furnaces. They had trouble time and again because tubes failed. It was almost always at the outside and about four inches from the terminal head. Nobody seemed to investigate the reason for it. One day these people called us up and said they wanted somebody to find out what was the trouble with their couples. I went over there and found that on practically all the tubes the glaze was gone about four inches from the terminal head and the tubes showed signs of deterioration at that point. We

finally traced it to probable condensation of the gases coming out, and we corrected it on the hypothesis that we were getting sulphuric acid at that point by the condensation. We put in porcelain tubes that were resistant to chemicals and from that time on their trouble disappeared. That is only to illustrate the point that if you have failures you should investigate carefully why failure occurs.

Another trouble was in a glass tank not over 2500 degrees F. The tube tapered right off. They had a very strong fluxing agent in the batch and that flux simply fluxed the tube down. This was corrected by using silica brick and by using "impervite" refractory primary and secondary tubes. Since that time there has been no destruction of tubes beyond ordinary wear and tear. I could cite innumerable similar instances that showed some particular condition that could be corrected. It was not the fault of the tube. There is usually some one combination that will give results. There is something that will stand these conditions and you can find it if you get the co-operation of the manufacturer.

Mr. E. H. Coxe:* I would like to ask what they use to measure the temperature of the electric arc.

Mr. R. W. Newcomb: The optical pyrometer. There is no other to use. The temperature of the electric arc has not been very thoroughly established on account of the limitations of any instrument for measuring it. If you could place the arc in a perfectly closed sphere and had an instrument with suitable calibration you could probably get pretty accurate results. The temperature of the electric arc under ordinary conditions is pretty hard to obtain.

Mr. W. M. Austin:† The author referred to the error in the electric thermometer reading of the gas temperature when placed close to the comparatively cold boiler tubes. Similar results have been obtained when testing electrical machinery for temperature rise above the surrounding atmosphere when carrying rated current. The specifications usually state that the temperature rise shall not exceed a certain number of degrees above a standard room temperature.

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When the temperature test is made in winter, although the temperature of the room is the same as in summer, the observed temperature rise may be several degrees less than is the case when the test is made in summer.

The explanation that we have made to account for this discrepancy is that in summer there is less difference in temperature between the warm machine and the walls of the building than in winter, and consequently there is greater radiation from the machine in winter. In a circuit-breaker carrying 8000 amperes direct current, this produced a rise in temperature of 30 degrees C. in summer and about 27 degrees C. in winter. The circuit-breaker was about 10 feet from a large window which was kept closed in winter and may have had a small opening in it in summer.

Mr. F. M. Van Deventer, *Chairman*: I am very glad that Mr. Newcomb mentioned the radiation error which occurs when taking temperatures in gases surrounded by surfaces which are cooler than the temperature of the gas stream. I believe that the lack of knowledge or proper regard for this error is responsible for more erroneous boiler-test reports than any other one factor.

Personal experience is the easiest to relate, and I shall describe my first introduction to the radiation error. In taking the exit gas temperature from a Babcock and Wilcox boiler, I found that the mercurial thermometer which I was using could be inserted through the top soot-cleaning hole, in which position there would be only one more row of boiler tubes to be traversed by the gases before entering the smoke flue. During the observations, we decided to check a thermo-couple outfit which we had, and, as it could not conveniently be put in the same location as the thermometer, it was placed in the smoke flue about three feet above the top row of tubes. It was naturally expected that the gases in the upper location would be possibly several degrees cooler than in the lower location, because of the extra row of tubes and the probability of cool air leaking in around the damper box. Observations of the temperatures, however, indicated a temperature 70 degrees higher at the upper location, instead of lower. Assuming one or the other of the instruments to be at fault, their positions were reversed and it was then found that the indicated temperature at the upper position was still 70 degrees higher

than below. Recalling that a bulletin had been published on this subject by the United States Bureau of Mines, I referred to Bulletin 145 by Kreisinger and Barkley, which Mr. Newcomb has also referred to, and there I found the explanation of our peculiar observations.

I believe it worth while to explain briefly the cause of this radiation error. Suppose that a thermometer be placed in a Dutch-oven type of furnace in which the gases, the charge, and the surrounding refractories are all at the same temperature. Then, the thermometer will indicate the true temperature in the furnace. Now suppose that a water-cooled plate be placed a few inches from the thermometer. Heat will flow by direct radiation from the hot thermometer bulb to the cool plate, and, as a consequence, the temperature indicated by the thermometer will tend to fall. However, as soon as the temperature of the thermometer bulb has begun to drop, heat will begin to flow from the surrounding gases to the relatively cooler thermometer, by conduction and convection. The temperature of the thermometer would continue to fall until a new temperature would be assumed such that a new state of thermal equilibrium would be established, which would occur when the amount of heat radiated by the thermometer to the cold plate would equal the amount of heat received by the thermometer from the surrounding gases.

In the case of the boiler which I referred to, the actual temperature of the flue-gases was about 650 degrees F. The temperature of the boiler tubes, which entirely surrounded the thermometer bulb, was about 350 degrees F. and the equilibrium temperature of the thermometer was 580 degrees F. If a test had been made under these conditions and the flue-gas temperature recorded 70 degrees lower than the actual value, the test would have indicated a boiler efficiency more than two per cent. higher than the actual efficiency, and I believe I am safe in saying that many of the tests which have been recorded in the past are from one to three per cent. high because of this error.

Mr. Newcomb described one means of reducing this error by surrounding the thermometer by a refractory shield. Theoretically, this method gives only a partial correction, since the shield will always be colder than the thermometer, due to the transmission of heat from the shield to the cooler surface. Practically, the value of this method of correction depends upon the difference in temperature between the

gases and the surrounding cold surface, and it may be entirely satisfactory in many cases.

In taking temperatures in the forward sections of a boiler where the difference in temperature of gases and tubes is great, the Kreisinger and Barkley method is the most satisfactory one. By this method, several thermo-couples of different diameters are inserted together. Since the amount of heat radiated from the thermo-couple to the cold surfaces increases with the size of the couple, it is obvious that if it were possible to fabricate a couple with zero diameter, there would be no radiation error at all. The temperature indicated by the smaller couples is higher than that indicated by the larger ones, and if the several observations are plotted, with diameter of couple as abscissa and indicated temperature as ordinate, a curve will be obtained which when extended back to the zero diameter ordinate will indicate the true temperature of the gases. The correction obtained by this method may be as high as 300 or even 400 degrees F., in the first pass or furnace of a boiler.

Mr. W. J. Merten: Mr. Chairman, does the curve you have drawn on the board which represents the one you obtained on your investigation obey the fourth power law of transfer of heat by radiation? It seems that the transfer by convection currents would seriously affect the results.

Mr. F. M. Van Deventer, *Chairman*: The curve does not seem to be logarithmic. When plotted on equal co-ordinate paper, it appears to be a logarithmic curve, and for that reason I used paper which was equally spaced horizontally and logarithmically scaled vertically, hoping to obtain a straight line which would indicate very accurately the true temperature at zero diameter. I found, however, that while this paper had a tendency to straighten out the line to some extent, the curve was still of the same general shape as before. It would take a real mathematician to attack the type of curve analytically, because the heat enters the thermometer by conduction and convection while it leaves by direct radiation. In the first case, the quantity of heat flow is a function not only of superficial area or diameter, but also the difference of the fourth powers of the temperatures of the thermometer and the surrounding surface. In the second case, the

quantity of heat flow depends upon surface or diameter and the first power of the difference in temperature between the gases and the thermometer.

MR. E. B. PLAPP:* I would like to ask the speaker just how he suggests protecting the thermo-couple in order to minimize this error due to radiation of heat from the couple to the cooler boiler tubes.

MR. R. W. NEWCOMB: In the case I mentioned they use two separate plates each side of the thermometer bulb and each baffle-plate consists of a thin steel plate lined with asbestos and separated by about 0.25 inch, spaced with small studs so there would be as little conduction as possible. There is a bare thermometer spiral between the two asbestos-insulated steel plates which are about 0.75 inch apart. Outside of these are the two other plates, also asbestos lined. The gases have a clean sweep between the two plates. That is the construction they use. I presume there is still loss of heat from the thermometer spiral to the baffle-plates.

There is one point in connection with the question just raised by Mr. Merten. The surfaces of the tubes that receive heat or lose heat affect the rate. The condition of the boiler tubes as well as the condition of the thermo-couple tubes will affect the heat balance, and will affect the application of the fourth power law.

MR. F. S. BLOOM:† I would like to bring up one question. What is the error due to the lack of use of compensating leads? Many operators find it expensive and, as supposed, not justifiable to maintain compensating leads on pyrometers installed for permanent use, and it is practice to install the couple through the wall of a furnace or flue using no means of compensation other than to adjust the indicating instrument for an approximate zero reading equal to the temperature of the atmosphere at the couple head. In this type of temperature indication, such as in gas-producer operation, accuracy under 50 degrees F. is not necessary.

However, the error may be much more than we have assumed. Suppose for instance, we have a nine-inch brick flue through which

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we insert an 18-inch couple to within three inches of the head on the outside, and that we have a temperature of 1500 degrees F. on the inside and 85 degrees on the outside. The couple wires terminate at steel posts inside the head of the couple where the temperature may be 150 to 200 degrees F. Where is the cold junction, inside or outside the couple head? What is the error if outside atmospheric temperatures are used as the cold junction temperatures?

Mr. R. W. Newcomb: Your cold junction is the place where your couple leads join the couple. In your couple you have a connecting piece between the thermo-couple and the connecting wires. The error is not due to the atmosphere as much as it is to the temperature of this little brass connector that serves as a connecting medium. If you have a connecting piece one inch long between your couple and the lead, you have several thermo-couples in one, because you have the hot junction of the element, another junction between the thermo-element and the connecting piece, and the connecting piece itself which also has thermo-electric properties, and a third junction where the piece joins on to your instrument leads. What you read on your instrument would depend on the characteristics of all three of them. It is essential to have the connecting piece where it joins on to the thermo-couple and where it joins on to the instrument leads at the same temperature. What the error is in the case you describe I can not tell you. There is no way of estimating it. You say 150 degrees. I would guess 400 degrees to be nearer it.

Mr. L. J. Reed:* The speaker has said quite a little about the contamination of different pyrometer ends. I should like to ask whether in the case of a platinum-rhodium couple the contamination will continue so that it is necessary to keep recalibrating it or whether it will reach such a constant condition that it can be calibrated as contaminated and used for some period of time afterwards.

Mr. R. W. Newcomb: That is rather a difficult question to answer. It depends on where it is contaminated and how it is used afterwards. If it is used always under the same conditions with the same temperature gradients it would slowly settle down. Theoreti-

*Test Engineer, Carnegie Steel Co., Duquesne, Pa.

cally, the purer a wire is, the greater is the influence of a slight degree of contamination. Any degree of contamination would theoretically affect it in about the same scale. But there is another factor that comes in here and that is that any wire which contains impurities from lack of refining in manufacture will hasten the deterioration of the couple. To answer your question directly I would say that you would gradually reach a point where the contamination would affect it less and less.

Mr. Philip Dressler: What Mr. Newcomb has told us about contamination of platinum by silicon, brings to my mind an interesting fact along the same lines. Dr. Jeffery, of the Champion Porcelain Company, Detroit, which makes the porcelains for the "Champion" spark-plugs, told me that about ten years ago he was making spark-plug porcelains in which they inserted the platinum directly into the green body and fired it right in. Very often the platinum wires melted down into a bead although the temperature did not exceed cone 10, or about 2300 degrees. This was very mystifying and he went to a great deal of trouble to get platinum wire from Heraeus in Germany thinking his trouble was due to a poor grade of platinum. This wire, however, behaved exactly the same way. It was not until afterwards that he discovered that he was getting a combination of platinum and the silicon which was produced when the silica in the porcelain body was exposed to reducing conditions in the kiln.

THE ENGINEER AND HOUSING PROBLEMS*

By L. Brandt†

The engineering profession generally, in the past, has not been sufficiently interested in housing, since many of our large cities were constructed along lines of expediency rather than on a broad comprehensive plan—first as villages which grew into boroughs and finally into cities. Most of our housing has been built up through the efforts of individuals, each aspiring for his immediate advantages without, it would seem, appreciable consideration of those who might have to live in the houses, or any consideration of future possibilities and developments. As a result, many of our communities are a jumble of buildings, streets and alleys, placed at random over the landscape, where in many instances attractive and beautiful places might just as well have been.

When the standards of living were on a lower scale, labor plentiful, and materials cheap, almost any kind of development sufficed. Since conditions have so materially changed in every respect, the call now is to build several hundred houses at a time, requiring acres of ground for a modern housing project. These demands, under present conditions, necessitate the application of real engineering science in order to meet the requirements of a higher standard of living, and yet provide economical housing.

Engineering has so much to do with the various phases of housing work, from its inception to the completion of an undertaking, that engineering talent should be more extensively engaged from the very start in consulting on land purchases, to the final financing of all housing projects.

When property is to be obtained for housing purposes, the first step is the surveys, then the planning of lots, streets, sewers, water-supply, gas and electric service, street paving, sidewalks and landscaping—all this in preparation of the building site, and all of which should be carried out with a perfect understanding of the entire improvements contemplated. These things require organized engineering skill.

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Extensive housing work can be summed up under four classifications:

1. Housing the coal industry.
2. Housing the steel industry.
3. Housing the manufacturing industry.
4. Housing the general public.

In some instances, especially the coal industry, the employer owns the home. Whether the employee shall be encouraged to own his home or houses are to be rented or sold to them, it is incumbent on industry to provide housing facilities with the same forethought, skill and attention that it employs in the building of plants and the selection of equipment for them. In order to handle the housing of a plant in the most economical way, consideration must be given to the following:

1. Purchase of acreage or building site.
2. Providing of utilities for present and future.
3. Town planning and preparation of site.
4. Intelligent house designing to fit the occupant and his income.
5. Specification of materials involving the least upkeep.

Here the engineer's work, in so far as the greater part of housing is concerned, begins. He must make surveys, lay out streets, provide for sanitary and storm drainage, plan sewage disposal and in many cases water-supply, and provide for other utilities such as electricity and gas.

In making surveys, planning or plotting ground, and laying out streets, the engineer must keep in mind the ultimate development and, above all, flexibility and control. Grades must not only be established to make property accessible and provide for sewage disposal, but to conform to the natural contours of the land to produce building sites that serve their purpose in the community without waste or requiring extensive grading and improvements. A lay-out planned with these things in mind will result in an attractive part of the community instead of just another plan of lots. Providing and protecting the water-supply for present and future needs, and the installation of a complete sewage system with the improvements of the streets through the most-used thoroughfares of the community, can usually be accomplished at less cost before the community is mostly built up.

A project handled along scientific lines always costs less than if handled in an unorganized manner. In the laying out of frontage, consideration must be given to the types of houses to be built, whether single, double, bungalow, or two-story type. One important thing to be borne in mind in connection with housing is that there is a big difference between commercial or industrial housing and what might be termed individualistic housing. Some large housing projects have wasted thousands of dollars trying to incorporate in industrial housing the adjuncts of special houses. Since the problem in commercial or industrial housing is largely one of cost and adaptability to the given requirements, it becomes necessary to incorporate therein materials which are readily available; to do this in such a manner as to eliminate waste as far as possible, and never, in any instance, to specify any materials except good standards of stock design and sizes. Materials should be specified only for the most economical use consistent with the type and class of house. All this requires a thorough and detailed knowledge of the building business, based upon the many controlling factors.

The first step in housing is that of financing, which undertakes:

1. Financing the purchase of the property and the development of the building sites.
2. Construction financing.
3. The purchasers' financing, which may be extended over a period of years.

In order to finance in an intelligent manner, the requirements of the home purchaser must be known—his earning power, the cash payments he is able to make, and the terms and monthly payments that must be made over a period of years.

The greatest consideration must be given in selecting the location for a housing project to serve an industry or a community, when such a location would involve transportation to and from places of employment, shopping centers, churches, and schools. The price paid for raw land should be low enough to allow for the improvements in utilities such as grading, sewers, water, and paving, so that the improved building lots will in no case exceed 20 per cent. of the total cost of the completed house and improvements.

In planning an industrial or a community housing project, the class and type of buildings should be well studied from the standpoint

of those who will occupy them, for the requirements may include all from the executives to the common labor, and in some cases this includes colored as well as the foreign element. Classes, sizes, and types of houses, and the prices for the houses and lots, will be determined by the initial and monthly payments the purchaser can undertake. In this connection the following schedule is apropos:

HOUSING ACTUARY

1	2	3	4	5	6	7	8	9	10
Cost of lot	Cost of house	Total cost of home	Reserve for taxes each month	Reserve for insurance each month	Reserve for upkeep each month	Monthly payments of principal, 6 per cent. interest 15-year term	Total payments each month	Additional monthly payments for 12-year term	Additional monthly ments for 10-year term
$ 500	$2500	$3000	$ 7.63	$ 0.55	$2.50	$22.44	$33.12	$3.59	$ 7.18
550	2700	3250	8.26	0.60	2.71	24.31	35.88	3.89	7.78
600	2900	3500	8.90	0.65	2.92	26.18	38.65	4.19	8.38
650	3100	3750	9.53	0.70	3.13	28.05	41.41	4.49	8.97
700	3300	4000	10.17	0.75	3.33	29.92	44.17	4.79	9.57
750	3500	4250	10.80	0.80	3.55	31.79	46.94	5.09	10.17
800	3700	4500	11.44	0.84	3.75	33.66	49.69	5.39	10.77
900	4100	5000	12.70	0.93	4.20	37.40	55.22	5.99	11.97
1000	4500	5500	13.98	1.02	4.60	41.13	60.73	6.58	13.17
1100	4900	6000	15.25	1.10	5.00	44.87	66.22	7.18	14.37
1200	5300	6500	16.52	1.20	5.45	48.62	71.78	7.78	15.55
1300	5700	7000	17.80	1.29	5.85	52.35	77.29	8.38	16.76
1400	6100	7500	19.06	1.38	6.25	56.09	82.78	8.98	17.96
1500	6500	8000	20.34	1.46	6.70	59.83	88.33	9.58	19.15

Land values of homes should not exceed 20 per cent. of the total cost of house and lot. Figures given in column 1 are fair averages.

Tax and insurance rates being dependent on local assessments and rates in force, should be adjusted accordingly. The amounts shown in columns 4 and 5 are rates in force in a metropolitan district, and are good averages.

The monthly payments of principal including 6 per cent. interest shown in column 7 are based on a 10 per cent. initial payment of amounts shown in column 3.

Payments shown in column 7 are based on the most liberal terms that should be considered. Columns 9 and 10 show additional monthly payments for shorter terms.

Sound values in land purchases, the improvements, and the building of houses that fit the purchaser's or renter's pocket-book provide the basis for successful financing. So much is dependent on the engineer's work in the first stages of a development that this phase of the problem should always be well understood by him.

As a general rule, except in the mining industry, engineers do not go into the question of house design, nor care to handle architectural work involved in a housing project, but in most cases the engineering departments of industrial enterprises are called upon to handle the housing problems of their companies. As it is necessary to place all housing on an economic basis as far as possible, the designs and speci-

fications for the improvement should be made to conform to the prices determined by the schedule. This work should be approached with recognition of some method or code for designing the houses to be constructed. The best method established in this work has been one that contemplates design efficiency, utility, and standardization. This method provides that the efficiency of the plan be figured on the basis of accommodating the furniture required for each room. Furniture must be accommodated in such a manner as not to interfere with heating, windows, electric switches, or lines of travel through the rooms. The minimum efficiency should be 75 per cent., on the basis of the inside area of all first-floor and second-floor rooms, or bedrooms, between plaster lines, omitting halls, stairways, and any space in excess of the following for closets and bath-rooms:

Bedroom closets, eight square feet (one to each room).
Hall or linen closets, 12 square feet.
Bath-room, 42 square feet.

Standards for designing should cover height of stories, dimensions of structural material, door and window openings kept to the fewest sizes, and proper selection of all materials for foundations, superstructure, and roof so that the various standards can be used throughout a large variety of designs to create a better labor productivity in the construction of the work.

Results obtained from efficient planning and standardization show in the following tables of unit costs in houses built during 1923.

Housing for Coal Industry. The houses in this group have cellars; eight-inch hollow-tile foundations; drop siding underlined with waterproof building paper, extra-heavy asphalt slate-surfaced shingle and asbestos-shingle roofs, and clear yellow-pine trim, stained and varnished.

Stories	Rooms	Room cost	Area cost	Cubic cost	Usable space cost	Efficiency
1	4	$408	$2.42	$0.138	$2.62	92.4%
1	5	378	2.38	0.15	2.58	92.6%
2	10	351	4.12	0.18	2.29	89.9%

Housing for Steel Industry. In this group two-story, five-room houses have been built, having eight-inch hollow-tile foundations on concrete footers, cement cellars, siding and shingle exterior, asbestos-shingle roofs, and complete plumbing, including laundry trays and hot-air heating systems.

Stories	Rooms*	Room cost	Area cost	Cubic cost	Usable space cost	Efficiency
2	5	$627	$6.76	$0.252	$4.41	76.6%
2	5	622	6.71	0.259	4.38	76.6%

Housing for Manufacturing Industry. In this group are considered two-story five- and six-room houses, having eight-inch, hollow-tile foundations with concrete footers, concrete cellars, siding and shingle exterior covering, asbestos-shingle roofs, and complete plumbing, including laundry trays and hot-air heating systems.

Stories	Rooms*	Room cost	Area cost	Cubic cost	Usable space cost	Efficiency
2	5	$683	$7.36	$0.275	$4.80	76.6%
2	5	697	7.53	0.29	4.91	76.6%
2	6	663	8.11	0.281	4.80	84.5%
2	6	630	7.71	0.28	4.76	81 %
2	6	631	7.73	0.276	4.83	80 %

Housing for General Public. In this group are represented a greater range of houses, varying in number of rooms and types of construction. However, the houses in general were built with concrete foundations, full cement cellars, brick-veneer construction, slate roofs, hardwood floors in the first story, tile bath-rooms, hot-air heat, built-in china closets, book-cases, clothes chutes, etc.

Stories	Rooms*	Room cost	Area cost	Cubic cost	Usable space cost	Efficiency
2	7	$970	$11.52	$0.412	$6.57	87 %
2	7	837	10.78	0.386	6.15	87 %
†2	6	1036	10.74	0.346	7.79	70 %
†2	6	1604	10.40	0.352	8.29	62.7%
†2	‡7	1641	8.54	0.388	10.24	69.7%
2	6	832	9.32	0.302	5.92	78.6%

It is not the purpose of this paper to enter into a discussion of houses for the general public, or to make any comparisons except to emphasize the importance of having a well-defined code to work to in designing houses. The above figures indicate considerable differences in efficiency in houses of about the same type, and just as great differences obtain in other types of houses as are shown under what we

*In addition to bath.
†Special non-code plans.
‡Hot-water heat. Stone veneer.

have termed public housing unless such a code is given consideration. The many controlling factors entering into a housing project from the raw land to the finished product, financing, and occupancy, have made housing appear rather complex, but if approached on a basis of complete understanding, which is mainly the result of applied engineering, the problem solves itself.

The housing problem is largely one of cost with which the engineers, in general, can be of great help. In order to keep costs within the purchasing power of the dollar it is necessary to approach the question on a basis of standardization and quantity production. These are not always fully controllable, due to the various building codes encountered. This, in turn, entails the standardization of building codes through the adoption of common-sense state housing codes, and, to accomplish this, engineers must use their influence and lend their active support.

All these things are necessary to solve the housing problem and to bring about the ownership of homes by the working classes, which no one can question is an incentive to good citizenship. Any movement that will stimulate home owning strengthens the commonwealth. Home ownership steadies and stabilizes, and this is a part of housing to which I have called attention. Whether the engineer realizes it or not, he is much concerned. The engineer, realizing his professional responsibilities to bring about better labor conditions for the industry he serves, can help by producing a home along the lines suggested in order that workmen may be more contented, and thus better citizens, and have a better outlook on life in general than they have to-day under the conditions generally existing throughout the country.

DISCUSSION

Mr. Howard N. Eavenson, *Chairman*:* Gentlemen, you have heard this very interesting paper by Mr. Brandt. Are there any questions? I know he will be glad to elaborate any of the points he has brought out and answer any questions that any of you may care to ask.

Mr. L. Brandt: I am very glad to come here and give the engineers anything that I have. Of course, there is considerable information in this paper I have here. I have developed what I call housing charts—the Bureau of Standards calls it "Method and Operation"—in which we have every move in a housing project charted, from the financing to the completion of the house, and from this we plan our work. This information we are glad to give anyone who is interested in housing.

Mr. Richard Hirsch:† I should like to ask if the figures given are based on 1923 costs of material and labor.

Mr. L. Brandt: Yes, 1923. I might say that in checking on 1913 as a pre-war basis of 100 per cent., we found in 1920 that the peak was reached at 260; in 1922 it dropped to 187; and in 1923, indicated 200. That is for wholesale building costs. You can control wholesale building costs, but you can not always control individual or retail building costs because we enter into various communities and the builders sometimes control too much of it.

Mr. Richard Hirsch: Could you give us some idea as to how much building has been done under this general plan, and the location of the various units?

Mr. L. Brandt: Under this general plan? I followed the building of houses for 16 years, or from 1900 to 1916, as a general contractor. At that time I was persuaded to take up professional work, but the World War came on us and, of course, we were not able to develop everything that we had in mind, and then reconstruc-

*President, Howard N. Eavenson & Associates, Pittsburgh.
†Mechanical Engineer, H. K. Porter Co., Pittsburgh.

tion came on after that. But we have built by this method, I would say, about 10,000 to 12,000 houses in different parts of the country. I have at the present time an operation on which I am consultant for a project at Buffalo, which is concerned with 300 houses. In this plant, we have scheduled normal output for labor—that is, we have laid out in each craft units of work that a man shall do in a day. There is much of the work that can be sublet—excavation usually by the yard, laying up of blocks, or brick at so much a thousand—but we have been able to introduce it into the carpenter work, and I will say that we finished houses under this system to-day as cheaply as we finished them in 1914, because we have been able to tax the labor in this plan. In the last two years we handled close to a thousand houses in units of 25 up to 300. We have small groups around Pittsburgh; some at Springdale, where we handled about 130 houses in groups of 10 to 50; also at West Pittsburgh, and on the Monongahela River. If anyone is interested in seeing some of the houses, we will direct him to the locations and arrange for a visit to the groups.

Mr. N. F. Hopkins:* It seems to me that the ratio (20 per cent.) that the speaker has placed as what he thinks should be the value of the ground, is too low, and that a better figure is from 25 to 30 per cent. Of course, a person may build a fine house on any land, and, as long as he is satisfied with the location and does not want to sell, it is all right; but, if he wants to sell, he must find a buyer who is also satisfied with the locality as well as the house. If there are many people who are satisfied with the location, then the value of the ground is high; if the contrary, then the value is low.

There seems to be a tendency on the part of real-estate men to adjust this in a way by making the out lots in a plan larger than the more desirable lots, so that what these out lots lack in value per foot front, they make up in area. It may be noted that in Pittsburgh the large lots in outer Penn Avenue are being sold, the old mansions torn down, and the ground subdivided and smaller houses and apartments being built. That is because the value of the ground has become too great as compared with the value of the house. As Mr. Schellenberg, a former member of this Society, once said, "Poor people live on the most valuable ground, because the rich can't

*Harrop and Hopkins, Pittsburgh.

afford to." In other words, a rich man likes to have some ground around his house, but can't afford to pay for it if it is desirable for tenement houses.

There are scattered apartment buildings in suburban districts. Some are in the midst of vacant lots, the value of the lots representing but a very small part of the value of the buildings; but, until the World War, these buildings usually lacked enough tenants, even at low rentals, to make the property pay.

Mr. J. M. Rice:* Mr. Chairman, I would like to ask Mr. Brandt a few questions. First, for some of the houses for which he has given us the unit cost, can he give us a tabulation in a slightly different way showing the cost of the land, cost of improvements to the land, and the cost of the house—that is, the percentage of the total cost involved. Secondly, I should like to know how he views the ready-cut house. There are quite a lot of arguments pro and con on that, and I should think that it would be helpful to us if he can give us his experience.

Mr. L. Brandt: I can not give you figures with reference to land improvements, just offhand. A great deal of that is handled outside my work. I handle principally the housing, and land improvement is usually handled through other engineering organizations. However, I will say that in a group of houses we had at Johnstown, a rather hilly piece of land and difficult to handle, we fixed the price at about $650 a lot as an improvement cost, and the land was not considered of any value except for the purpose we used it for. We built houses of concrete construction, with double walls. They were very successful and cheaper than a brick house considering the group we had and the place we had to build them. The lot cost, you understand, was very low when you consider that we built $5000 and $6000 houses on lots where the land value was $600.

With reference to the ready-cut houses, it is the same as applying machinery to anything, but the trouble with a lot of ready-cut houses has been that they have been sold through catalogues, and turned loose on the purchaser who knew very little about erecting them. The ready-cut house is successful if the manufacturer will

*Consulting Engineer, Pittsburgh.

erect the house, if that will answer your question. Otherwise, the average builder can cut it on the ground as cheaply as he can pick out the material.

Mr. J. M. Rice: That is what I wanted to find out; whether your experience indicated that it was economy in the housing operation—not for the individual house, but for, we will say, 50 houses—to purchase this material ready cut rather than to attempt to build it up from the ground.

Mr. L. Brandt: In that case I would ready cut it on the ground. We usually do that for a group of houses.

Mr. E. W. Pittman:* Are those houses completely detailed and all pieces cut to exact size previous to shipment, or is sawing and cutting done in the field?

Mr. L. Brandt: You mean the structural part of the house details?

Mr. E. W. Pittman: Yes.

Mr. L. Brandt: No, not completely.

Mr. E. W. Pittman: You don't make sketches of the house?

Mr. L. Brandt: In each piece of timber that is necessary. We standardize our floor joists. For these we have thousands of pieces the same length and the same cut, and we very often make our floor systems with two lengths of joists (not over three) and they are interchangeable throughout the different houses.

Mr. E. W. Pittman: You don't have to saw them off on the ends?

Mr. L. Brandt: No. They usually come from the saw-mills sufficiently trimmed.

*Engineer, Pittsburgh.

Mr. Winters Haydock:* Mr. Chairman, I would like to ask the speaker to discuss a little further the economic phases of the housing problem, particularly as related to what he calls "individualistic building". The speaker has mentioned the fact that there are two classes of housing operations which are constantly going on—industrial housing, in which he is actively engaged, and individual housing operations. I would like to hear him express his opinion as to whether the individuals can safely invest in housing at the present time and under present conditions of cost, and expect to profit in the long run. You all recognize the fact that a very serious housing shortage still exists. Now, under present conditions of labor and material costs, is it wise for the individual to invest in housing without having looked forward to a slump in costs in the future? Are we not sure to get such a slump, in which case the individual who invests now will find that he has to take a loss?

Now, to what extent is housing being held up to-day on account of the lack of capital available for "individualistic building"? Is not this lack of capital the real thing that is preventing the housing shortage from being relieved; and is not that lack due to a realization on the part of those who have money to invest that present labor costs are clear out of reason and that material costs also are much higher than they should be? Then, again, to what extent are present conditions due to unreasonable requirements imposed by union labor upon the building industry? That last may be an embarrassing question but I think it a very important one in its bearing upon the economic phases of the housing problem.

Mr. L. Brandt: With reference to future costs, that is pretty hard to answer. We view it this way—the present rate for labor being high is going to remain high for some time. Lumber, the basic material entering into house construction, is growing scarcer every year. We are cutting it at the rate of 45,000,000,000 feet a year and we are not growing much of it. You cannot expect lumber to be much lower. I cannot see that we are going to have much lower costs in the next five years, and I say five years because I believe we will not have caught up with the demand in five years, and as long as the demand exists, we shall have to supply a large number of

*Chief Engineer, Citizens Committee on City Plan of Pittsburgh, Pittsburgh.

houses. That is going to keep the price up. In other words, if we can stabilize the price where we have it to-day I believe that is about where we will find it in the next five years. Now, that is all a question for the individual, whether he should invest and have the use of the building for five years.

With reference to labor, I believe you refer to the high price of labor. I refer to it as non-productivity of labor. I have had that matter under discussion with labor a great deal, and have discussed it with some of the largest labor leaders in the country. If we can find a man big enough to organize labor on a basis of service, then wages will not matter so much. Here and there we have found it possible to obtain normal output from labor, and then our costs go down. As I told you, we are finishing small six-room houses in dollars and cents as cheaply as we did in 1914, because we have taxed labor to do it. In other words, we have put the workmen on a partly piece-work basis.

Mr. Winters Haydock: That is not union labor, is it? Union labor refuses to work on a piece-work basis, doesn't it?

Mr. L. Brandt: In my experience last year over the country in projects I have been handling, about 50 per cent. of them are handled by non-union labor. The men applying for work on these larger jobs want to know whether it is union or non-union, and in many cases they will come back and say, "we don't want to work on the job if it is union, because we are coming to see about work, to earn good wages, and we want to work without interference". We have, of course, open-shop jobs, where the union men walked off, but it was just about fifty-fifty, and in about two weeks time there were 200 men put on the work. These were non-union men, and they produced. Now, the individual is willing to produce. Ninety-five per cent. of them are honest, but if labor is organized and has service as its policy, the organizer who accomplishes it will be the biggest man in the country.

Mr. Richard Hirsch: Are you able to use non-union labor in the large cities?

MR. L. BRANDT: We are using it in Buffalo, and it has been used in the immediate vicinity of Pittsburgh.

MR. RICHARD HIRSCH: Is not Buffalo a more or less non-union city, generally speaking?

MR. L. BRANDT: It is about 70 per cent. union, I would say, but it is not far from Canada and on a large job you can interest men in Canada. Did I answer your question?

MR. RICHARD HIRSCH: Yes, thank you.

MR. F. M. VAN DEVENTER:* Mr. Brandt, you have stated that you believe the building index for the next five years will be around 200. In the light of that fact, if you were building a home in one of the suburbs and expected to live in it for, say, ten years and then sell, what figure would you assume for value depreciation; that is, would you charge off one per cent. or two per cent. a year in anticipation of such a shrinkage in value, or would you consider that it would be possible to sell at nearly cost price at that time?

MR. L. BRANDT: That is a pretty hard question to answer. If you occupy it as a home, or build for investment it is a different story. As a home, we have in our schedule here one per cent. for upkeep.

MR. B. A. LUDGATE:† Does that include repairs and maintenance?

MR. L. BRANDT: Yes, and we do not figure depreciation. Some try to amortize a frame house over a period of 30 years. That is good practice, I think.

MR. W. C. IFFARTH:‡ In figuring the cubical content of the house, do you always include the basement?

MR. L. BRANDT: Yes, from the floor of the basement to the under side of the roof sheathing.

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†Assistant Engineer, Pittsburgh & Lake Erie Railroad, Pittsburgh.
‡Chief Engineer, Harbison-Walker Refractories Co., Pittsburgh.

Mr. W. C. Iffarth: In figuring the efficiency of the house, do you use your own plan, or is it used by architects in general?

Mr. L. Brandt: It is our own plan. We have worked it out. It is simple enough when you understand the usable space, the efficient space, and the access to such efficient space.

Mr. H. Briggs:* Could you give me any information as to the variation in insurance rates of houses of the brick-veneer type and of the type in which brick is backed up by tile?

Mr. L. Brandt: In building a row?

Mr. H. Briggs: Yes.

Mr. L. Brandt: I would prefer the brick-veneer over frame. We have found a little moisture and seepage in the four inches through the brick and the four inches through the tile. You cannot always make it waterproof and a little seepage will work through and make spots on the plaster. Your brick may be impervious and good brick, but sometimes mortar joints are a little weak or a little thin, and we found that the brick-veneer is better for a small house. The brick-veneer house over frame costs about two per cent. less than the brick over tile.

Mr. J. D. Underwood:† What percentage of the cost of constructing a building is properly to be charged as labor?

Mr. L. Brandt: We have tried to figure all the labor that enters into the cost of the house, and the total labor represents 94 per cent. of the building cost, but to-day we find that about 33 per cent. is the field labor.

Mr. B. A. Ludgate: In the various kinds of houses—mining and industrial—what kind of lumber do you use mostly, white pine, yellow pine or hemlock?

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†Engineers' Club of Baltimore, Baltimore.

Mr. L. Brandt: The framing material used in houses to-day is principally yellow pine. We have very little hemlock that we can depend on. In the cheap houses, such as mining houses, we use yellow pine for exterior siding and trim, and we are using considerable fir. Fir is coming into this market now in competition with yellow pine. I rather like the fir—that is, the higher grades. It takes a little more paint, but it is a better job, and when we get into the better houses we use a percentage of white pine for trimming, but the white pine is what is known as Western white pine, and a good bit of it is hard and brashy. Redwood has been introduced to some extent. If you can properly season redwood it is all right, but when you have to kiln-dry it, it is not a very satisfactory material, so the basic material, you might say, is yellow pine for the frame lumber, flooring, sheathing, and so on.

Mr. F. A. Stevens:* Mr. Brandt, how does the cost of plastering over wall board or plastering over the metal lath and the wood lath compare?

Mr. L. Brandt: The wood lath is much the cheaper. In some of our work, we are plastering at a cost of about 45 cents a yard. That is in outlying districts. In Pittsburgh it is running about 85 cents a yard for the same plaster work, and that is over wood lath. Metal lath is too expensive and the wall boards, as a plaster base, are more expensive than wood lath. We have tried to use wall boards instead of plastering, and we have had some very successful jobs, but we have found that the contractors give us considerable trouble because the plasterers will not work for a contractor who is using wall board in any of his jobs, so we have been restricted somewhat in the use of wall board due to the fact that contractors hesitate to use it.

Mr. F. M. Van Deventer: We have had a number of discussions in the Club Room concerning the relative merits of diagonally laid sheathing and horizontally laid sheathing. The proponents of diagonal sheathing claimed greater structural strength and resistance to wind strain, etc.; while proponents of horizontal sheathing

*Draftsman, H. H. Robertson Co., Pittsburgh.

claim equal strength at less cost. I would appreciate your comments on that subject.

Mr. L. Brandt: In a small house we find the horizontal to be much better. The diagonal wastes too much as the labor cost is high. We have sufficient bracing from the plastering lath alone without the necessity of putting on diagonal bracing. There is a certain amount of value in diagonal bracing, of course.

Mr. J. M. Rice: Is it not a general rule that the poorest people live on the most valuable land because the rich cannot afford to? I think you see that illustrated to some extent out Penn Avenue. Now, what is your practice in development; do you build the low-priced houses on the accessible land close to the plant and reserve the back lots for the more valuable houses?

Mr. L. Brandt: In specializing on industrial houses, we might revert to an old development along that line. The first model industrial town that was built in Western Pennsylvania, I think, was Vandergrift, Pa. You all know where this is located, on the Kiskiminitas River. The better part of the town was built adjacent to the plant and the cheaper section of the town was built back on the heights. The town has been successful, it has worked out successfully from the standpoint of having the better part of the town close by. Of course, they have no transportation there and there is a question of subdividing. The land that you have to work with, the industry you have to serve, the civic center, the community you are building around, and so on, are bound to increase the price or protect the values of land that should be worth more to some people than others. Now, I have never found anyone willing to pay more for a piece of land than it is worth. It is a rather difficult thing to deal with; one may have paid too much for the acreage, but we find that industrial plants will buy enough for their plant and future expansion, and forget about the houses until too late, and some real-estate man will come in and pick up the acreage and speculate on it and make a profit without improving the land. That is a point which I have included in my paper to-night—that the industries should take an interest in the housing whether they build the houses or not.

Mr. G. W. Quentin:* I overheard a conversation to-day. Assuming that a man could pay a monthly rent of $75, how much cash would he need to start the house and how much to carry it?

Mr. L. Brandt: In my table, including taxes and upkeep, $77.29 is the nearest figure I have to it. With 10 per cent. down, that means $700, he could buy a $7000 home.

Mr. J. M. Rice: Does that include the lot?

Mr. L. Brandt: Yes, that represents $5700 in the house and $1300 in the lot.

Mr. J. M. Rice: Is that possible within a 30-minute ride?

Mr. L. Brandt: Yes, you can buy lots, I think, within 30 minutes ride of Pittsburgh.

Mr. J. M. Rice: Is that based on paying in 10 years?

Mr. L. Brandt: No, 15 years. Ten per cent. down and 15 years to pay the balance.

Mr. B. A. Ludgate: What progress is being made in putting on the market a satisfactory "fuel-oil" heating furnace?

Mr. L. Brandt: Well, that is now low enough in cost, either for installation or maintenance. It is a question of building up the service. I think probably it may come unless the price of oil becomes prohibitive. Anthracite is going up, so soft coal will have to help us out for the present.

Mr. Howard N. Eavenson, *Chairman*: Are there any further questions? Gentlemen, it is always a very great pleasure to hear a paper of this kind from someone who knows what he is talking about, and I know I express the unanimous sentiment of the meeting in thanking Mr. Brandt for coming here, and for preparing this paper for us.

*Sales Engineer, Duquesne Light Co., Pittsburgh.

RECENT DEVELOPMENT IN THE USE OF HIGH-PRESSURE AND SUPERHEATED STEAM*

By B. N. Broido†

Introduction. The history of the development of the steam-engine has been mainly a constant struggle to increase the working pressures. After a beginning with the insignificant pressure of only a few pounds per square inch we gradually arrived a few years ago at a figure of about 250 pounds per square inch in stationary power-plants and about 200 pounds for boilers in marine and locomotive service. Only about three years ago tests were published of an experimental plant, extending over a period of 10 years, with pressures up to 850 or 900 pounds per square inch. Since then the progress has been rapid.

Successful experimental tests were reported from England with a Benson boiler operating above the critical pressure—that is, 3200 pounds per square inch. Soon we will have in this country two or more plants with units operating at 1200 pounds. In Sweden one boiler of 1000 horse-power designed on entirely new principles is generating steam at 1500 pounds per square inch, and a second boiler of 2500 horse-power and the same pressure is being built. The question in everyone's mind then is, what is the most advantageous pressure? We know of a number of plants under construction or in project where the designers originally considered high pressures of 600 pounds and above, but after careful study and consideration of stage feed-water heating and stage steam superheating, have decided on 375 to 400 pounds at 700 degrees, due to the present limited knowledge and the uncertainty as to all factors involved.

The object of this paper is to show the practical difficulties with high pressure and what has been done up to date in order to overcome them. It may, however, not be out of place to touch briefly on the theoretical advantages of high pressure and how it can be applied in practice.

Theoretical Advantages of High Pressure. It is well known, from the laws of thermodynamics, that the thermal efficiency of a heat engine depends chiefly upon the temperature range; that in

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accordance with the Carnot cycle the temperatures at which heat is supplied and withdrawn should be as widely separated as possible. Since this principle has been recognized by engineers, there has always existed the tendency to increase the temperature range of the steam—that is, to increase the temperature at which heat is absorbed and lower the temperature at which heat is rejected. It has led to the recognition of well defined limits—a maximum temperature of about 750 degrees F. defined by the materials at present available for boilers, superheaters, turbine blades, etc.; and a minimum condenser temperature of about 80 degrees F. corresponding to 29 inches of vacuum. This temperature is so near the usual cooling-water temperature that a higher vacuum would require disproportionately large quantities of circulating water.

In accordance with the Carnot cycle, the maximum efficiency is obtained when all the heat is absorbed at the highest temperature and all the heat to be rejected is discharged at the lowest temperature. If this could be realized in the steam-engine within the above given limits, or if all the heat were transferred to the steam at 750 degrees F. (or 750 plus 460, equal to 1210 degrees F. absolute) and all heat were rejected at 80 degrees F. (or 80 plus 460, equal to 540 degrees F. absolute) the Carnot cycle would be realized and the efficiency of the engine would be $\frac{1210 - 540}{1210} = 0.553$, or more than one-half of the heat would be transferred into mechanical energy.

The rejection of all heat at the lower temperature can be nearly approximated, as the temperature of the condenser remains the same while the steam is condensing. It is, however, impossible to cause the steam to absorb all heat at the higher temperature. In the boiler the water is first heated to the steam temperature and heat is absorbed at a gradually increasing temperature; if the steam is superheated the process of superheating also takes place at rising temperatures. Only the latent heat or the heat of evaporation is absorbed at a constant temperature corresponding to the prevailing pressure. This heat is a larger part of the total heat transferred from the coal to the steam. It is, therefore, evident that the higher the pressure the higher is the temperature at which the bulk of heat is absorbed by the steam, the more nearly we approach the ideal condition of the Carnot cycle, and the higher is the thermal efficiency of the process. The following table shows the values for pressures from 150 to 1200 pounds:

TABLE I. VARIATION OF STEAM CHARACTERISTICS WITH THE PRESSURE

(Steam taken dry saturated and expanding adiabatically to 0.3 pounds per square inch gage pressure.)

Pressure Pounds per square inch gage	Temperature saturated steam Degrees F.	Entropy	Total heat in live steam B.t.u. per pound	Total heat in exhaust steam B.t.u. per pound	Heat available by expansion B.t.u. per pound	Ratio of heat available to total heat at high pressure	Increase over amount at 150 pounds per square inch Per cent.	Specific volume at high pressure Cubic feet per pound
150	366	1.5615	1195	1020	175	0.1464	.....	2.753
200	388	1.5398	1199.2	1006	193.2	0.1611	10.0	2.138
300	422	1.5089	1204.7	985	219.7	0.1820	24.3	1.479
400	448	1.486	1208	970	238	0.1970	34.6	1.125
500	470	1.469	1210	958	252	0.2085	42.4	0.906
600	489	1.4517	1211	946	265	0.2186	49.3	0.757
800	521	1.4264	1210	929	281	0.2320	58.5	0.567
1000	547	1.403	1207	913	294	0.2438	66.5	0.453
1200	569	1.382	1201	899	302	0.2515	71.8	0.373

The first column gives the pressure in pounds per square inch; the second, the corresponding temperatures in degrees F. for saturated steam. The sixth shows the theoretical maximum heat available by expanding the steam adiabatically to 0.3 pound per square inch gage.

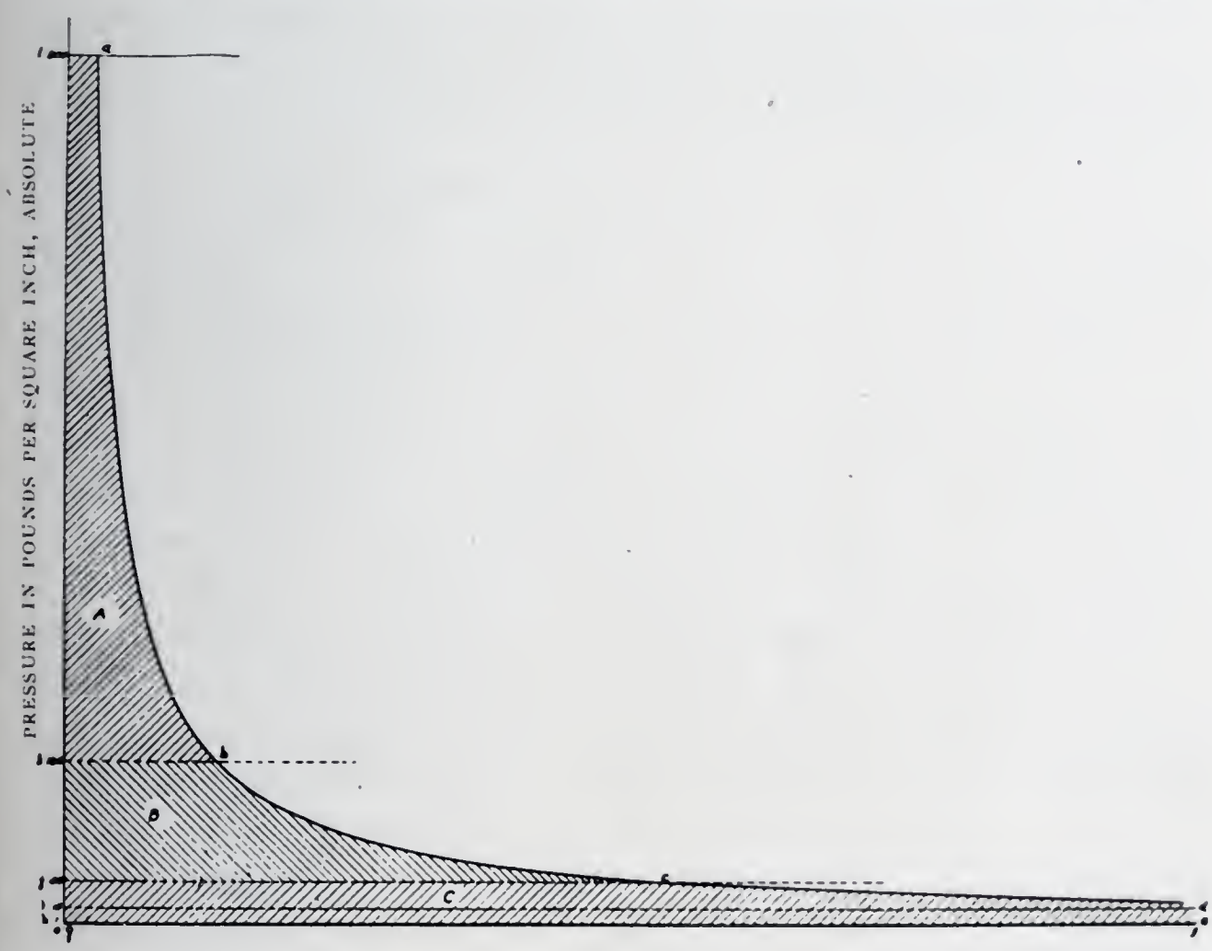

Fig. 1. Pressure-Volume Diagram.

The eighth column gives the percentage of increase of heat available over that of 150 pounds pressure. The other columns are self explanatory.

Pressure-Volume Diagram. The advantage of higher pressure can also be clearly seen from the pressure-volume diagram shown in Fig. 1. It also indicates how this advantage varies with the conditions under which an engine is being operated.

Curve *ad* represents the change in volume of steam when it expands adiabatically from 800 pounds pressure to 29-inch vacuum, the last part of the expansion curve being omitted in order that a larger scale could be used. The area *bdefh* represents the work done by steam when expanding from 150 pounds to 1 pound absolute. This area is shown in the diagram with letters B and C, while the area *abhi* (area A) is the additional work which could be obtained if the initial pressure of the steam were 800 pounds. The gain of the higher pressure could be therefore expressed as $\frac{A}{B + C}$. Assuming another engine working with live steam at 150 pounds pressure, but exhausting against 40 pounds, the work done will then be represented with area *bcgh* or area B. If the initial pressure of this engine were 800 pounds, the additional work would be again represented by the area A, and the increase in efficiency could be expressed as $\frac{A}{B}$. It is much greater in any case than the first engine, as B is much smaller than $B + C$.

This indicates that the advantage of high-pressure steam increases considerably as the back-pressure increases. Consequently, the extra high pressure is especially advantageous in all industrial plants which use steam for power generation and also for heating and process work, such as chemical works, sugar refineries, etc. This point will be discussed further in a subsequent paragraph.

It is evident that the economy of every existing steam plant may be considerably increased by using an additional steam-turbine, or an additional cylinder for a reciprocating engine working at high pressures, the exhaust steam from which can be utilized in the existing turbine or cylinders. If the exhaust steam from the additional unit has the same heat value as the live-steam at the pressure in the existing plant, it is clear that the capacity of the prime mover has been increased by the amount of power developed by the additional unit,

while its increased energy will have been obtained with the smallest possible fuel consumption, or practically the theoretical amount corresponding to the energy developed. As a matter of fact, the efficiency may be even higher, and depends upon the whole economy of the existing plant; the lower this is, the higher will be the steam or fuel consumption, so that the higher the thermal efficiency of the added high-pressure unit as compared with that of the existing plant, the greater will be the increase of power for the same fuel consumption. The gain in energy expressed in per cent. is in reality so considerable that the figures are apt to be startling.

High-Pressure Boilers. The opinion was very openly expressed that the greatest difficulty in the application of very high steam pressures would be the construction of suitable boilers. Little concern has been voiced as to the use of high-pressure steam in reciprocating engines, but doubt has been expressed as to the possibility of utilizing the extended range in heat in turbines, due to the greatly increased losses in the blades. Turbine losses become greater as the pressure of the steam is increased because losses in the turbine blades, due to friction and leakage, increase as the density of the driving medium increases. Fortunately, great progress has been made in eliminating the difficulties encountered in the design of high-pressure boilers and turbines.

A careful study and analysis of boiler performance, particularly with respect to the heat absorption and water circulation, has thrown more light on difficulties expected with high-pressure boilers and also has shown how to eliminate these difficulties.

Investigations regarding the properties of boiler materials, the influence of the manufacturing process on the strength of the material, the progress in the production of special steel plates, and their treatment for the manufacture of boilers, all were important factors in the design of high-pressure boilers. The latest developments in superheaters were along the lines which made them adaptable to high pressures and temperatures. The designs of valves and fittings have also so far advanced that they can be made suitable for enduring severe conditions in connection with high pressures.

Recent investigations of boiler materials have shown that heretofore important points were not sufficiently taken into consideration when selecting test-bars in the usual manner and making the tests for

determining the strength. It was, for instance, found that the strength and composition of plates are poorer at the edges than at the middle. This is an important point in the case of plates for boiler drums, as the riveted seams are made along the weakest parts of the plate—that is, near the edge. Serious boiler defects have repeatedly occurred due to the failure of plates which at the test seemed to conform with the official regulations, but later proved defective. A careful analysis has also shown that plates which were originally satisfactory underwent alterations in the course of manufacture or under operating conditions. It was found that the pressure exerted when riveting was generally far too high, so that invisible cracks developed in the structure and the strength was reduced. The gradual alteration of the strength of a plate which is stretched when cold beyond its elastic limit is also an important factor to be considered. The effect of recrystallization through cold stretching which occurs usually at higher temperatures should not be overlooked in connection with high-pressure boilers. When the boiler is in operation, alterations similar to those mentioned may occur through temperature stresses due to the difference in temperatures at various heating surfaces, or between the inner and outer surfaces of the drum. These damaging influences become more important as the boiler pressure and the thickness of the plates increase, particularly because of the greater difficulties of riveting and machining. Higher evaporation rates have a similar effect, as they offer greater temperature difference, and additional stresses in the material are likely to occur.

The remarkable tendency toward higher pressures, which is clearly manifested to-day, will compel manufacturers to find suitable kinds of boiler materials. The capacity of machines and qualities of materials from which they are to be made are at present the most important question in modern engineering, and it will probably be some time before these questions are definitely solved, though considerable progress has already been made.

The latest investigations have taught us that riveted drums which require shaping and bending of plates when they are cold should not be used for high pressures, say above 800 pounds, and only drums forged from one piece should be applied. There are concerns in this country, as well as abroad, which are successful in manufacturing such drums. Fig. 2 shows a drum manufactured in this country by the

Bethlehem Steel Company and other companies. Fig. 3 shows a few drums in process of manufacture. Steels of a special quality with different percentages of nickel have been suggested for manufacture of high-pressure boiler drums. The firm of Krupp in Germany has

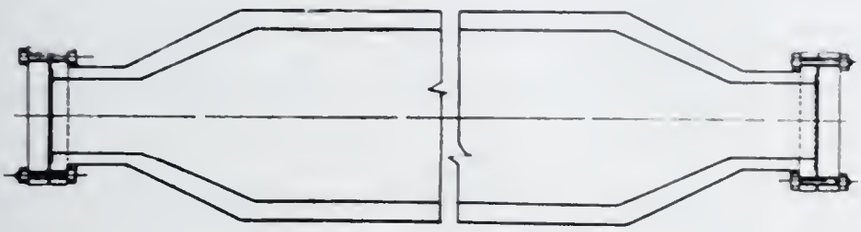

Fig. 2. Steam Drum.

developed two kinds of steels with five and three per cent. nickel, respectively. The tensile strength and yield-point of nickel-steel are considerably higher than those of open-hearth steel at temperatures

Fig. 3. Steam Drums in Process of Manufacture.

which are encountered in high-pressure boilers. Fig. 4 shows the tensile strength and yield-points of different kinds of steel taken at temperatures from 0 to 1100 degrees F. Those with the five per cent.

nickel are taken from tests made by Krupp, while the others are the results of tests of steel in this country. Drums made of nickel-steel with the above quality, and forged in one piece without seams, are unquestionably the most suitable for very high steam pressures and correspondingly high temperatures. Further test results on different types of steel are given in the Bulletin of the Prime Movers' Committee of the National Electric Light Association, June, 1924.

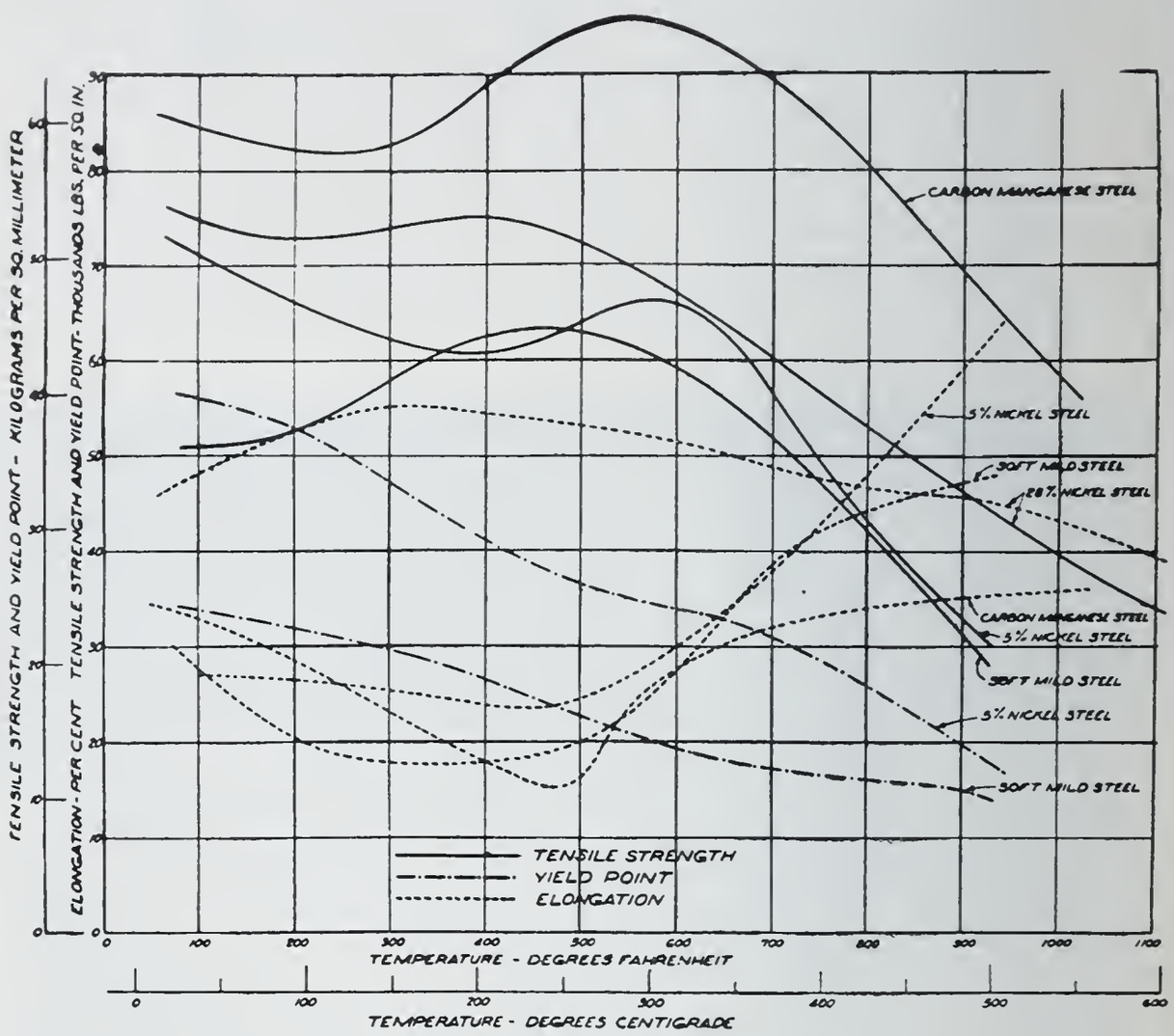

Fig. 4. Physical Properties of Various Steels.

A great many inventors have attempted to solve the problem of generating steam at high pressures for industrial purposes (among others, the well-known De Laval, Serpollet, and White), but with very little success. In most of these cases the "series" or flash type of boiler was used, the water entering the boiler at one end and leaving it at the other as steam, so that there was no storage of surplus water in the boiler, thus precluding the risk of explosion. On the other hand, it is evident that the removal of scale and sediment from

the inside of the small tubes is very difficult, if not impossible. This type of boiler has but very limited application, and then only in small units for experimental purposes. One boiler-manufacturing concern in this country which made experiments with high-pressure boilers also started with a small tube "series" boiler. It was found, however, that this type of boiler is not suitable for power-plants, where larger units are considered and where load fluctuations are unavoidable, and a change was made, therefore, to a boiler similar to the standard horizontal, sectional, cross-drum, water-tube type with straight tubes.

The first successful boiler for a pressure above 800 pounds per square inch was built and put into operation about 15 years ago by Dr. W. Schmidt, of Germany, who has attained prominence in his work in connection with superheaters and who has experimented with

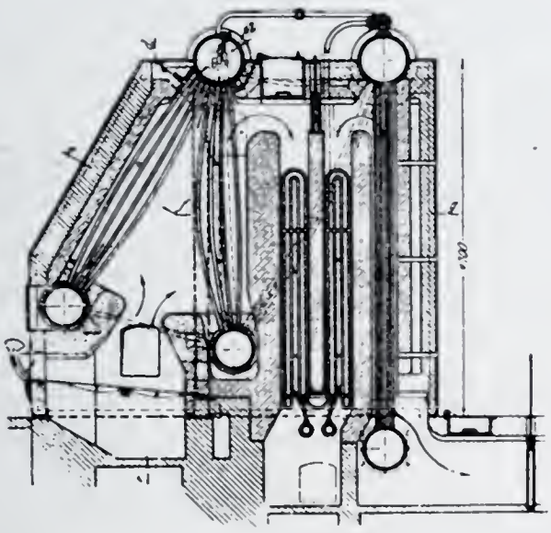

Fig. 5. High-Pressure Boiler.

high-pressure and high-temperature steam for over thirty years. The boiler was of the multiple-drum, semi-vertical type with bent tubes (Fig. 5).

The much-debated question as to where the superiority lies between the semi-vertical and the horizontal water-tube boiler will also be argued in connection with high-pressure boilers.

As regards elasticity, the sectional, horizontal, water-tube boiler has appreciable advantages. In comparison with other types, this boiler retains a predominating position owing to its safety, facility of cleaning, possibility of standardizing, etc. It cannot be denied, however, that the sectional boiler in comparison with the vertical or semi-vertical type suffers from a serious defect—that is, the restrained

circulation, as the area of the headers and the circulating tubes between the headers and the drum is comparatively small. The question of water circulation is of particular importance in connection with high-pressure boilers, not only for the safety of tubes, but also because any temperature difference may cause excessive stresses in the headers and drums.

Multiple-drum, semi-vertical, high-pressure boilers are considerably more expensive than single-drum, horizontal boilers, as the price of the forged drum, particularly if made of nickel-steel, is very high. On the other hand, the importance of the number of joints in a boiler increases in more than direct ratio to the increased steam pressure. With high-pressure boilers it therefore seems advisable to eliminate as far as possible any hand-holes, especially because for these boilers small tubes are used, which would require a greater number of hand-holes for the same amount of heating surface.

For reasons of cost and design, the size and number of drums of high-pressure boilers (say above 1000 pounds) will be reduced to a minimum, which, in addition to the small tubes, makes the water and steam space of the boiler insufficient for the ordinary load fluctuations. It therefore becomes necessary to supplement the boiler capacity by some adequate and inexpensive means for storage. Fortunately, there are excellent means available, for the accumulation of energy up to any desired amount, by storing steam in water with increasing pressure and discharging it under falling pressure.

For example, the author figured a 1200-pound pressure boiler with a 36-inch drum and found that at a peak-load the pressure in the boiler may drop as much as 300 pounds if it requires five minutes for the boiler operator to adapt the supply of fuel to the stoker to suit the rush demand for steam. With coal and mechanical stokers it may take fully this time before the conditions of burning are sufficiently adjusted. The provision of an accumulator between the high-pressure and low-pressure stages of the turbine will reduce the pressure drop to a permissible amount. By means of the accumulator, the water space is separated from the boiler and placed in a separate container in which the steam is accumulated and stored under pressure. As it is not necessary that the accumulator should be built to stand the high pressure of the boiler, full use can be made of the peculiar property of

the hot water of accumulating much more steam at low than at high pressure for a given boiler pressure.

The most widely known accumulator is of Swedish design, that of Dr. Ruth's system. It is built in the form of cylindrical containers with hemispherical ends. It is filled with water up to 90-95 per cent. of its capacity. Sections through the accumulator are shown in Fig. 6. To insure a uniform heating of the water, the entering steam is mixed with the water by means of charging nozzles and circulating pipes.

From the description above it is evident that although the accumulator can be charged with superheated as well as with saturated

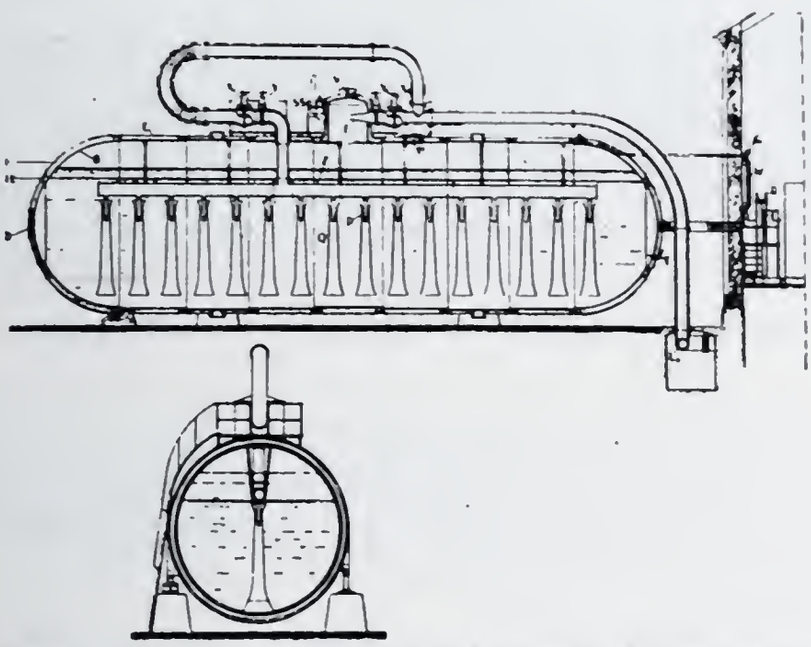

Fig. 6. Cross-Sections of Ruth's Steam Accumulator.

steam, it can deliver only saturated steam. In certain cases it may be desirable to have an accumulator that can furnish superheated steam. The accumulator is then provided with a second container, so that one is storing the latent heat and the other the superheat of the steam.

Superheaters. The latest development in superheaters was along the lines which made them adaptable to high pressures and high temperatures. Up to recent years, superheaters in water-tube boilers were located practically exclusively above the main bank of tubes or between the first and second gas paths. In this location the temperature of the gases was sufficient for comparatively low superheat. The superheat obtained in this location varied with the rating of the boiler. At higher ratings the superheat was higher, due to the increased amount of gases at a higher temperature; also the greater velocity

of the steam. At low ratings the superheat will drop. For low average superheat, these temperature fluctuations are of little consequence, as, in any case, the final temperatures are not excessive.

With increased pressure and superheat, constant temperatures are imperative, as any temperature fluctuations cause additional stresses in the prime mover, which may become detrimental. In Europe, special temperature regulators were designed and were often applied with superheaters for high temperatures. American engineers have approached the problem from another standpoint. Proceeding from the fact that any load variation applies to both boiler and superheater, as the same amount of steam which is generated by the boiler passes to the superheater, the superheat will be constant if the heat absorbed by both boiler and superheater varies in the same proportion. On the other hand, it is a known fact that the first few rows of boiler tubes generate most of the steam, so that a superheater located between or near these tubes will be subjected to the same variation as the part of the boiler where most of the steam is generated, and in this way the ideal conditions for constant temperature are closely approached. This arrangement was first applied in the large 2647 horse-power boilers at the River Rouge plant of the Ford Motor Company. The remarkable results obtained with this installation have caused the designer of the superheater to apply the same principle in other types of boilers. Since then a number of installations with superheaters in this location were put in operation, everyone of which has borne out this theory. Thus it seems that the acme in superheater design for high pressures and temperatures is attained. It has been questioned whether superheaters located in zones of high gas temperature are safe for high pressure. It should, however, be borne in mind that the higher the steam pressure and the denser the steam, the more cooling effect it has on the metal walls of the superheater tubes.

With the rapid increase in pressures and superheat, the question of steam velocity in the superheater elements attained more importance, as the life of the elements and the efficiency of the superheater depend upon the steam velocity in the superheater. High steam velocity keeps the inside of the elements clean, preventing accumulation of scale, which becomes more objectionable with higher pressure of the steam, as the metal temperature of a superheater unit in contact with the hot gases is established somewhere between the temperatures of

the gas and the steam. The higher the velocity of the steam and the cleaner the pipes inside, the nearer is the metal temperature to that of the steam.

With many superheater designs the elements consist of one tube of commercially available length, and, in order to obtain the desired superheat even with a double-pass superheater, a great number of elements are required with a correspondingly low velocity. The elements of the more recently developed modern superheaters are long enough to furnish high superheat with a high steam velocity. This

Fig. 7. Steps in Manufacture of Superheater Return Bends.

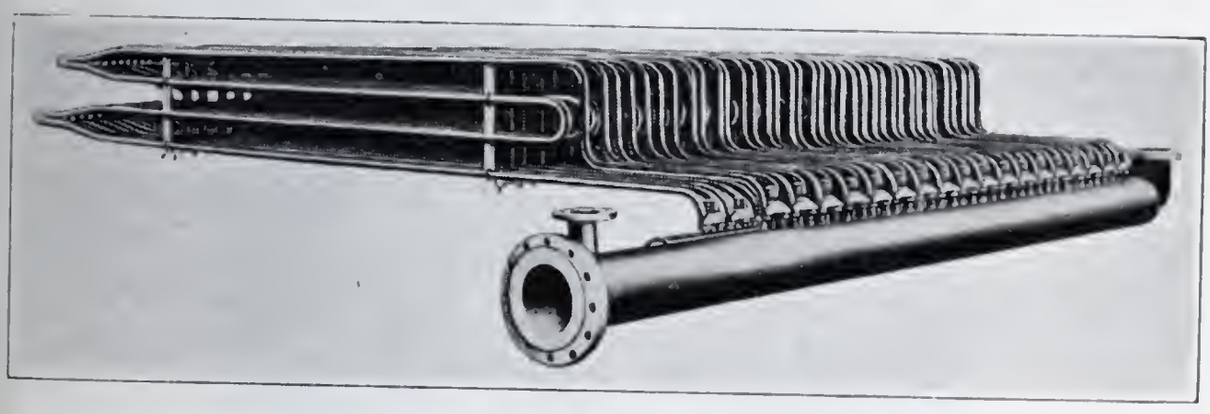

Fig. 8. Superheater Units and Headers.

was made possible by joining two or more pipes and making them continuous by means of the forged return bends, which are made out of the metal of the tubes, by a special forge-welding process, without the use of electrical or other autogenous welding. Fig. 7 shows the return bends, while Fig. 8 illustrates the entire element. These bends have also the advantage that the metal is thickened at the ends of the element, the bend itself being actually stronger than the body of the pipe. The sharp return bend breaks up any slugs of water which may enter into the superheater units, and gives assurance that no water can be carried over to the main line beyond the super-

heater. This is particularly important for the present large modern boilers with large overratings.

Units and Header Joints. Due to the fact that the surfaces of a superheater are exposed to high-temperature gases and depend for their cooling upon the flow of steam, internal stresses are occasioned in the superheater structure. This is aggravated by the fact that as steam becomes superheated, it absorbs heat less readily. No matter how properly a superheater may be designed, its service is always more

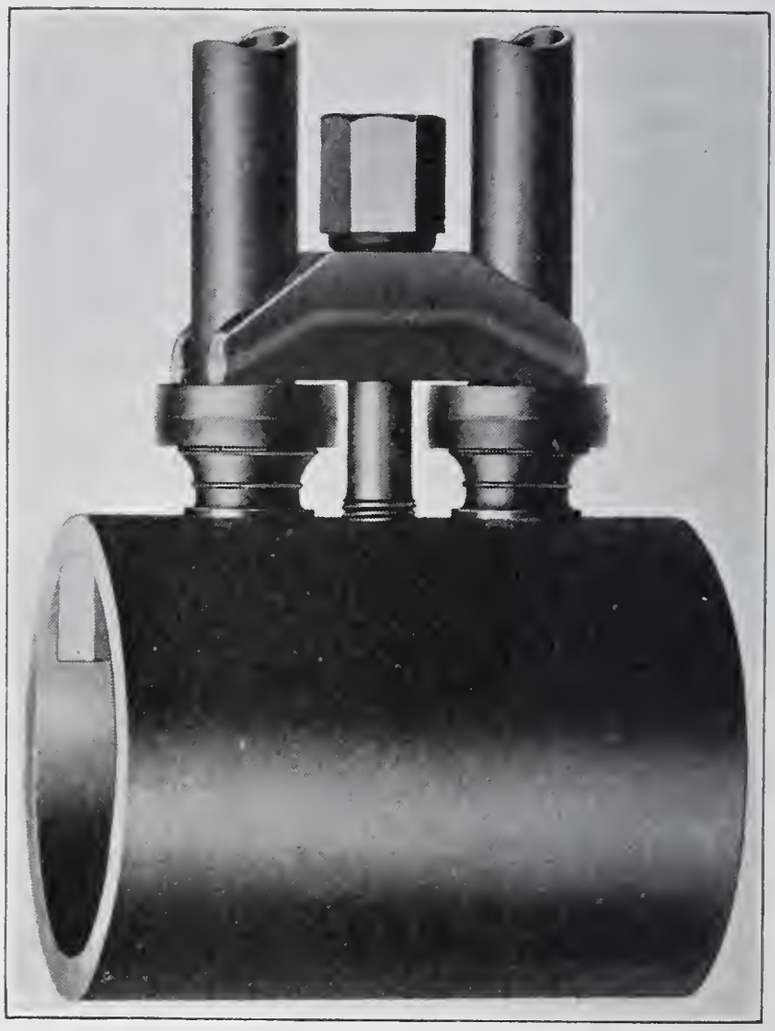

Fig. 9. Ball-Clamp Joint for Superheater.

severe and more apt to cause disturbances in operation than in the case of boiler design. This applies to any superheater, but particularly to those for modern boilers designed for high pressure and high temperature.

An up-to-date superheater, adaptable to modern requirements as to pressures and temperatures, must be so located that it is easily accessible so that it can be adjusted or inspected and boiler operation

resumed in a minimum of time and with a minimum of cost. It is extremely important that all parts shall be accessible for inspection, and those parts which by any chance may be subject to leakage of steam must be within convenient reach for correction or replacement.

The headers and joints must be located outside of the boiler, so that they can be inspected without entering the setting. The well-known bolt-and-clamp joint is applied. When necessary, a unit can be removed in a very short time and without entering the boiler setting, thereby avoiding the necessity of cooling off the boiler and then firing up again. The ball-clamp joint shown in Fig. 9 was originally developed for locomotive superheaters, where the conditions are very severe. With the development of the present high-duty boilers for stationary power-plants it was also adopted for connecting the elements to the headers of the high-duty superheater, and, after a short time, has convinced power-plant engineers that from an operating and maintenance standpoint it is superior to any other form in use. The bolts used in connection with this joint are heat-treated high-tensile steel, thus making this connection stronger than a rolled or welded joint. This joint is, therefore, most adaptable to high pressure and high superheat, because of the strong expansion forces occurring in the superheater units, which have to be resisted by the joint.

With the high-pressure boiler and superheater the number of joints in any part carrying high pressure should be reduced to a minimum. An additional advantage of the ball joint is that no other opening is necessary for applying or removing a unit, in contrast with the widely used rolled joint where a hand-hole is required opposite each unit connection.

Due to the many advantages and remarkable success of the ball-joint connection, it is to be expected that in the future it will be universally recognized as the ideal joint for superheaters for high pressures and temperatures.

High Pressure in Reciprocating Engines. It is a well known fact that in any double- or multiple-cylinder reciprocating engine, the high-pressure cylinders are the most efficient, so that when high-pressure steam is used the higher the pressure the higher is the efficiency of the first cylinders. The first tests made with high-pressure steam were with reciprocating engines, and remarkable results were obtained. In a four-cylinder engine of 150 horse-power, the steam

being re-superheated before entering the low-pressure cylinder and expanding to three pounds, absolute, an indicated horse-power was obtained with 2070 kilogram calories (8220 B.t.u.). The steam consumption was 5.22 pounds per horse-power, the initial steam being at a pressure of 800 pounds and temperature of 815 degrees F. or 294 degrees of superheat, with a condenser vacuum of 28.5 inches. The steam was re-superheated above the second cylinder to 600 degrees, and above the last low-pressure cylinder to 400 degrees. Taking into consideration the live steam required for re-superheating, an indicated horse-power was obtained on only five pounds of steam. These results are probably the best that were ever obtained with a reciprocating engine, and can hardly be improved upon.

Different types of cut-off valves were tested in connection with high-pressure steam, including slide-valves, piston-valves and poppet-valves. It seems that the piston-valve is best suited for steam at very high pressures and temperatures.

Particularly in cases where the engine exhausts against a back-pressure the conditions are very favorable to high pressure, only a comparatively small cylinder being required for even large capacities.

High-Pressure Turbines. With steam turbines the conditions are the reverse of those with reciprocating engines, the efficiency of the high-pressure stages of modern turbines being considerably lower than that of the low-pressure stages. Engineers were, therefore, somewhat in doubt regarding the benefit of high-pressure steam in turbines.

Even turbine designers themselves admit that a steam-turbine, as a rule, will not work economically in the area of the higher steam pressure, and for that reason they have tried to use the low-pressure area to the best possible advantage by raising the vacuum to the utmost. Up to the present time, a maximum pressure of 250 pounds per square inch and total temperature of about 700 degrees have been used almost exclusively. This pressure and temperature are lowered as soon as possible in one Curtis wheel or in two large single-bladed impulse wheels. At full load, the pressure after the first expansion stage usually is only 75 to 85 pounds per square inch. At partial loads the pressure is diminished proportionately. Even at full load this expansion is not economical, and it is still worse at partial load. High pressure drop and high temperature drop in the first stage were con-

sidered advisable in order to have the turbine casing subjected to as low pressures and temperatures as possible. The wide reduction in pressure and temperature necessarily requires high steam velocity at the outlet from the blade. As the circumferential speed is limited, the relation between steam velocity and circumferential speed becomes abnormal, which seriously affects the efficiency of the blades.

After it was established, however, that in reciprocating engines the advantages of high pressure are even greater than the theoretical consideration would indicate, turbine manufacturers were compelled to investigate means for increasing the efficiency of the high-pressure stages in order to utilize to advantage the higher pressures. Two paths were open to them—one to design high-pressure turbines with very high speeds, small diameters, and a small number of stages; the second, to design types with a considerable number of stages and very low steam velocities, say about 20,000 feet per minute. In order to make it possible to design the high-pressure area of a turbine with approximately the same high efficiency as that of the low-pressure area, it is necessary to make the high-pressure part independent of the other stages and develop it to a separate exclusively high-pressure turbine. This was done in every case where a high-pressure turbine was designed. The efficiency was increased by means of one of the above-mentioned methods.

The De Laval Steam Turbine Company, in Stockholm, Sweden, designed and put into operation a back-pressure turbine of 600 horsepower, with an initial steam pressure of 50 atmospheres (735 pounds per square inch), 788 degrees F. and 44 pounds back-pressure. The turbine consists of five rotors, and makes 6000 revolutions per minute. The generator is geared to the turbine and the number of its revolutions is reduced.

The firm of Brown, Boveri & Cie has also developed a high-pressure turbine to work in conjunction with a turbine of standard pressure. This turbine is also designed for a high number of revolutions per minute and is also geared to the generator. The diameter of the rotor is very small and the steam enters the rotor over its entire periphery. The circumferential speed is much lower than that of the standard turbine, so that losses due to wheel friction and ventilation are considerably reduced in spite of high pressure.

Fig. 10 is a diagrammatic sketch of a 10,000-kilowatt, high-pressure turbine and generator. It consists of four high-pressure

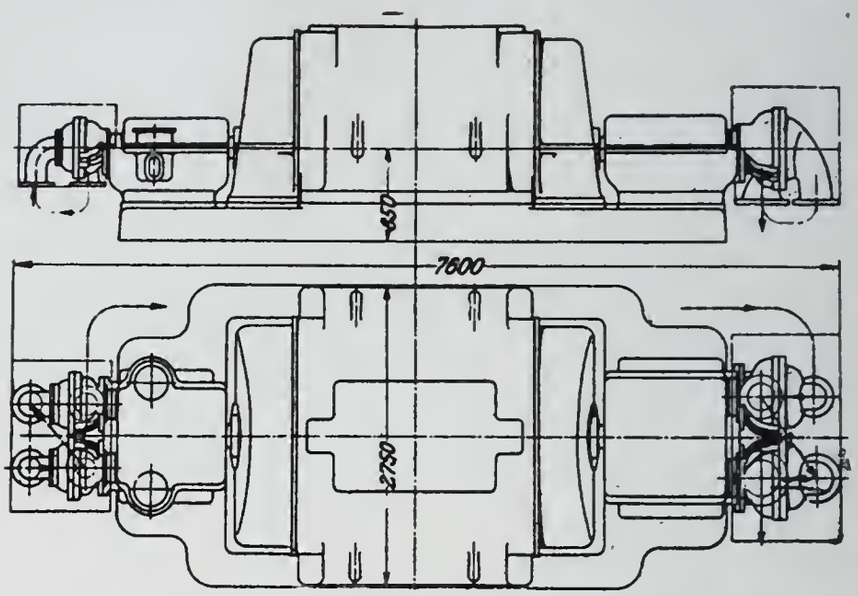

Fig. 10. High-Pressure Turbine and Generator.

rotors, as indicated on the sketch. A section of one of these rotors is shown in Fig. 11.*

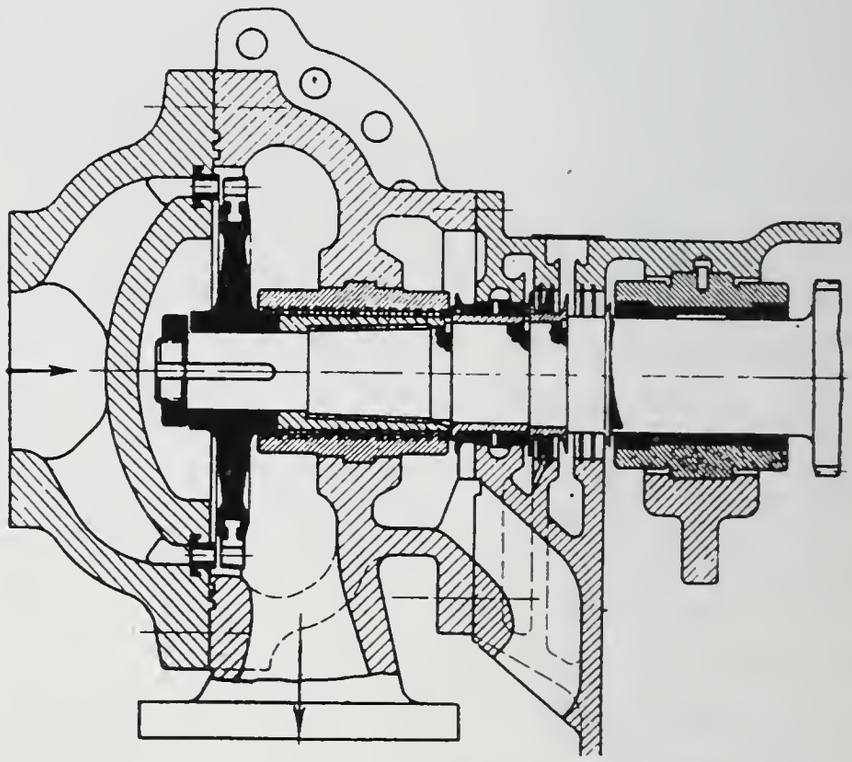

Fig. 11. Section Through Rotor of Turbine.

High-pressure turbines based on other principles of design are being built by a well known concern in Brünn (Czechoslovakia).

It is a known fact that manufacturers of Parsons turbines, also

*Zeitschrift des Vereines Deutscher Ingenieure, Dec. 29, 1923, v. 67, pp. 1153-1157.

of reaction turbines, have introduced a quality figure which applies for the whole turbine. It is the coefficient $\frac{\Sigma U^2}{H}$, in which U is the peripheral speed of the blades, and H is the total heat drop. The quality figure is the measure of the relation between the square of the circumferential speed of the blades and the square of the steam velocity that can result from the heat drop. Investigations show that the quality figure for the high-pressure part of a turbine is far below the figure for the low-pressure part. The designers rather expect that the low-pressure part will make up for the losses in the high-pressure part. In order to make use of the high-pressure heat drop in a steam-turbine so that the efficiency will be at least equal to the efficiency of the low-pressure heat drop, it was found necessary to raise the quality figure of the existing construction to a very considerable extent if the values of the low-pressure part were to be reached or exceeded. To that end, the Brünn concern has also segregated the high-pressure part from a single-cylinder turbine and developed it into a special high-pressure machine. The design is characterized by the flat course of the efficiency curve, which is very important for variable loads.

Careful study and tests made by this concern have shown that a high quality figure $\frac{\Sigma U^2}{H}$ is needed for the high-pressure part and there is considerable differenec in the way in which this is reached. It is claimed that there is quite a distinction between the heat drop in one large wheel or in a few large wheels with high circumferential speeds. It is also claimed that it is very essential that the wheels should obtain steam around the whole periphery, and that, if this is not the case, the part where there is no steam admission will have such a ventilating effect that the flowing of the steam in the admission part will be seriously interfered with, and this effect becomes more pronounced with increasing steam pressure.

Extensive tests made by the above company have also shown that the passing of steam from one wheel to another of a different diameter causes surging shocks even at velocities far below the sound velocity. For the same velocity these surging shocks are more violent with higher pressures, due to the greater density. The smaller the radius of the steam-flow curvature and the less gradual the difference in the successive wheel diameters, the more severe are the surging shocks.

From this, one can conclude that it is essential for a high-pressure turbine that the steam velocity should be lower as the steam density or steam pressure becomes higher.

As a result of these experiments the Brünn concern developed a high-pressure turbine consisting of a number of stages with a low expansion in each stage.

Careful tests made with such a turbine installed in a sugar factory in Nestomitz (Czechoslovakia) have shown that the diagram efficiency of the high-pressure part was 84.2 per cent. and the overall efficiency was 82.4 per cent. with an initial steam temperature of 750 degrees F.

Regenerating and Reheating. An advance in the direction of increasing the thermodynamic value of the heat in the steam, without unduly increasing the maximum temperature, is being made by increasing the mean temperature of heat reception. One method of effecting this is the adoption of regenerative feed-water heating by using steam tapped off successive stages of the turbine.

If a perfectly regenerative process could be employed for heating the feed-water, the efficiency of the cycle for saturated steam would be brought up to that of the Carnot cycle. In such a process the steam tapped off has been expanded, doing work in the turbine down to the temperature at which it is required to heat the feed-water. Since a certain amount of heat is required for this purpose in any case, the work obtained from the tapped-off steam is obtained merely at the expense of additional heat equal to the work done; or, in other words, at 100 per cent. efficiency. Expressed in another way, the utilization of some of the heat of the steam to heat the feed-water reduces the amount of heat that is lost by condensation in the condenser. A slight practical objection to such a system of feed-water heating is the additional complication of the pipe-work involved if a sufficient number of feed-water heaters in succession are employed to approximate the thermodynamically reversible process; but, even with two or three stages, considerable heat economy can be effected. The economic gain is due to the fact that the latent heat of the "bled" steam which has already performed work is absorbed by the feed-water and returned to the boiler, so that it is not wasted in the condenser. This method of stage heating feed-water is not new. That it has not been extensively applied is because heating the feed-water to a high degree requires

certain changes in the boiler and furnace. By recovering the liquid heat of the water, the last part of the boiler, as well as the economizer, became superfluous and some other means had to be applied to utilize the heat of the exit gases. This is now often done by the application of air heaters.

The higher the feed-water is heated by steam bled from the turbine, the higher must the air be heated in order to utilize fully the heat contained in the flue-gases. Up to the present time there has been considerable objection to having the air enter the furnace at high temperatures, on account of the increased maintenance cost of the brickwork. The recent tendency toward water-cooled walls eliminates this objection.

One advantage is not generally recognized. In the matter of turbine design there is an inclination to increase as much as possible the capacity of a turbine for a given number of revolutions. It is limited by the amount of steam that can pass the last blade wheel at a certain vacuum and at certain exit losses. By decreasing this amount of steam, the possible maximum capacity of the turbine is increased.

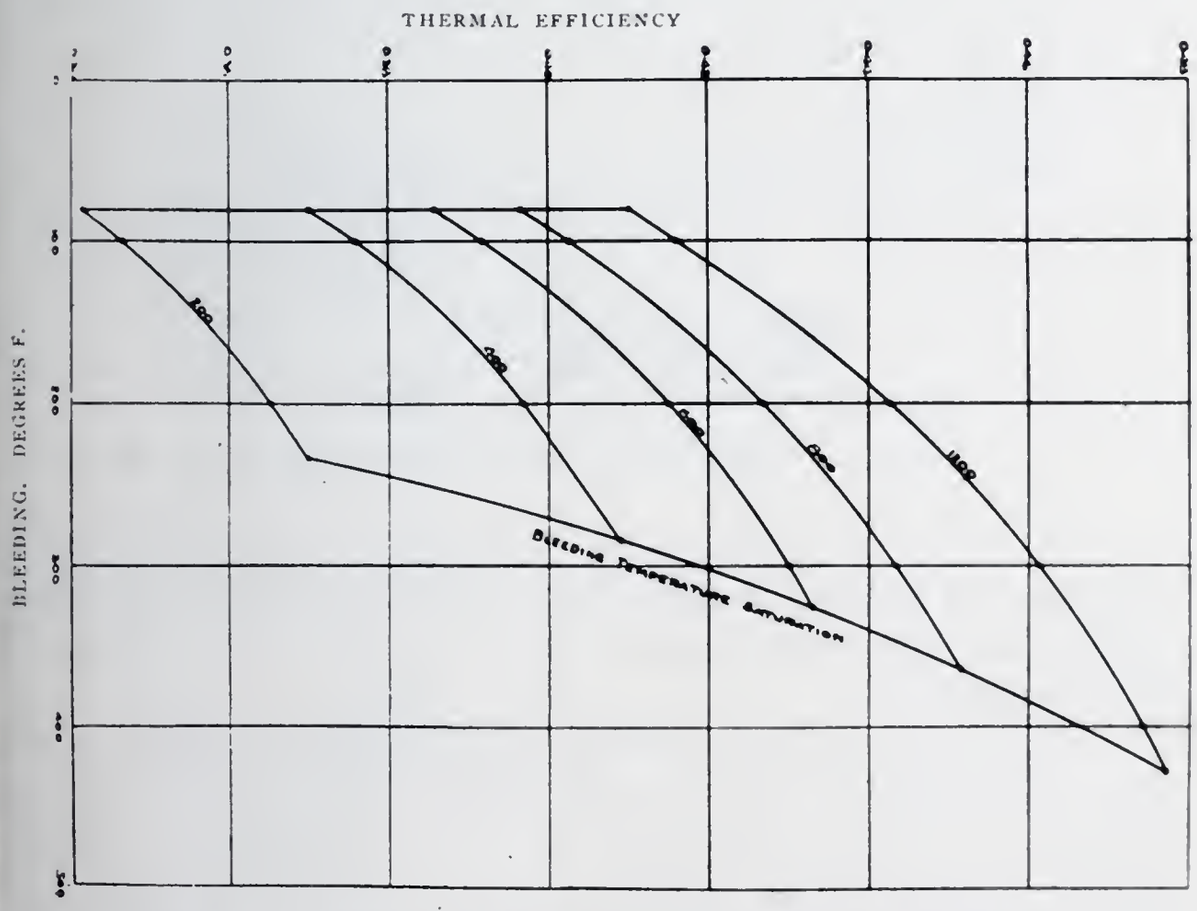

Fig. 12. Diagram Showing Increase in Thermal Efficiency Due to Stage Heating.

With stage heating, the steam flow through the turbine is gradually decreased, thus decreasing the capacity limiting factor. This is the more pronounced, the higher the initial steam pressure. For instance, at a pressure of about 1500 pounds, 47 per cent. of the steam must be bled from the turbine in order to heat the water to the maximum temperature.

The efficiency of the regenerative cycle is higher in proportion to the number of stages which are bled. For practical reasons this number is, however, limited from two to four. In many cases this number is sufficient even for high pressures. If the feed-water is heated by steam bled at three different stages, the gain derived from any additional stage is comparatively slight. With five stages we very closely approach the theoretical maximum possible, although there are other advantages besides the increase in efficiency to be obtained by bleeding many stages. Fig. 12 shows the increase in efficiency obtainable by stage heating for different temperatures and different steam pressures.

There were, until recently, two ways of accomplishing the regenerative cycle:

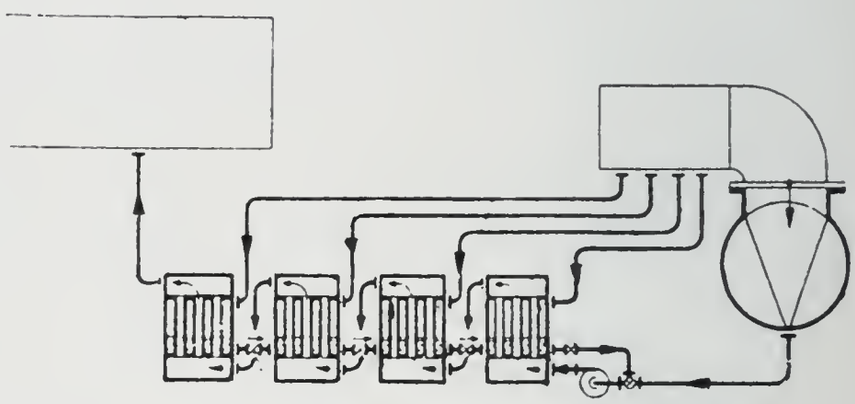

Fig. 13. Closed Feed-Water Heaters in Series.

1. To have the water raised to the boiler pressure by a pump. It passes then to as many closed feed-water heaters as the number of stages bled, while its temperature increases nearly to the temperature of the steam bled.

2. To have the water flow to open feed-water heaters where they come in direct contact with the water. In this case, the pressure of the water can not be higher than that of the steam so that a separate pump is required between each two stages in order to raise the water to the pressure of the next higher stage. Fig. 13 shows an arrange-

ment of a number of feed-water heaters in accordance with the first method. One of the disadvantages of both the above arrangements is their complication.

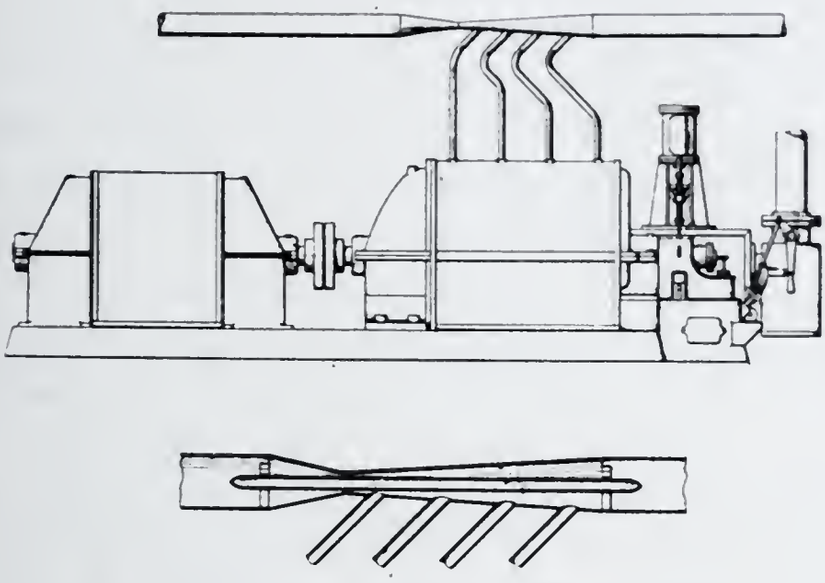

Fig. 14. Venturi Stage Feed-Water Heater.

A new arrangement, recently suggested, seems to have overcome the difficulties. It is illustrated in Fig. 14 and 15. With this arrange-

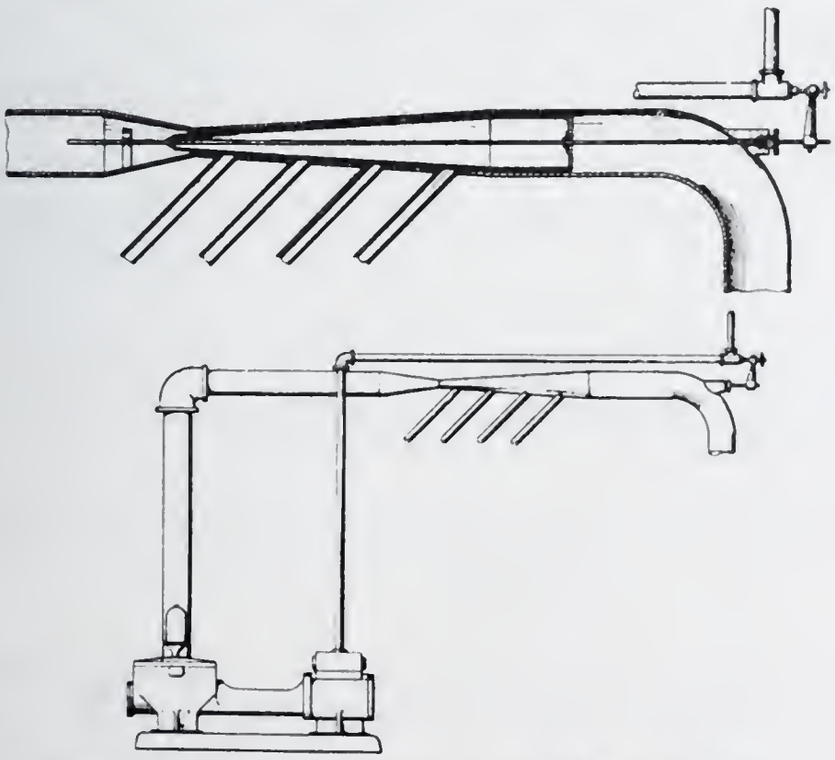

Fig. 15. Detail of Venturi Feed-Water Heater.

ment, neither multiple pumps nor multiple heaters are required. The water to be heated is raised to a pressure enough higher than the boiler

pressure so that friction losses through the device will be taken care of. This may be done by a standard feed-water pump. As shown in the illustrations, the feed line is gradually reduced in cross-sectional area to a small size, and then gradually increased again to the original size of the pipe, similar to the reduction and increase of area in a Venturi meter. As in the Venturi meter, the operation of the device depends upon the law of hydraulics that the sum of static head, pressure head, and velocity head at any point in a pipe-line are equal to the sum at any other point, disregarding losses.

The section must be sufficiently reduced so that the pressure is less than the steam pressure of the lowest stage of the turbine from which steam is to be bled. The steam from this stage is introduced at this point and heats the feed-water to the temperature corresponding to the pressure. At a point farther along the gradually increasing section where the pressure, although higher than at the first point, is lower than the steam pressure of the next higher stage of the turbine from which steam is to be bled, this steam is introduced, raising the temperature of the water to the temperature corresponding to the steam pressure. Steam from as many stages of the turbine as desired is thus introduced at points along the increase in area, in each case the water pressure being less than the steam pressure, so that the steam from the turbine can enter and mix with the water. After the last point of introduction of steam, the area of the cross-section is still further increased so that the velocity head is transformed back to pressure head sufficient for the water to enter the boiler. With this arrangement it is possible to heat the water by bleeding from many stages without undue complication, as all that is necessary for each stage is a pipe connection provided with a check-valve between the heater and the turbine, so that all advantages in connection with multiple stage heating can be obtained in a comparatively simple manner. It may be worth while to mention that this new development is now made public for the first time.

A second method of increasing the mean temperature of heat reception is re-superheating or adding further heat to the steam after it has passed a few stages and its temperature is reduced. This could be profitable only when carried to such a point that subsequent adiabatic expansion in the turbine to the condenser vacuum would leave the steam just saturated. Such a method was proposed many

years ago, but the mechanical difficulties in the way of its complete realization would appear insurmountable. An approximate solution, however, is being worked out at the present time. In some installations, the steam, after a certain amount of expansion in the turbine, is extracted and raised again to a high temperature in a reheater before re-entering the turbine. Reheating has also the additional advantage of extending the range within which superheat exists and of diminishing the range where moisture and consequent loss by water resistance, due to increased viscosity, exist; in other words, reheating is

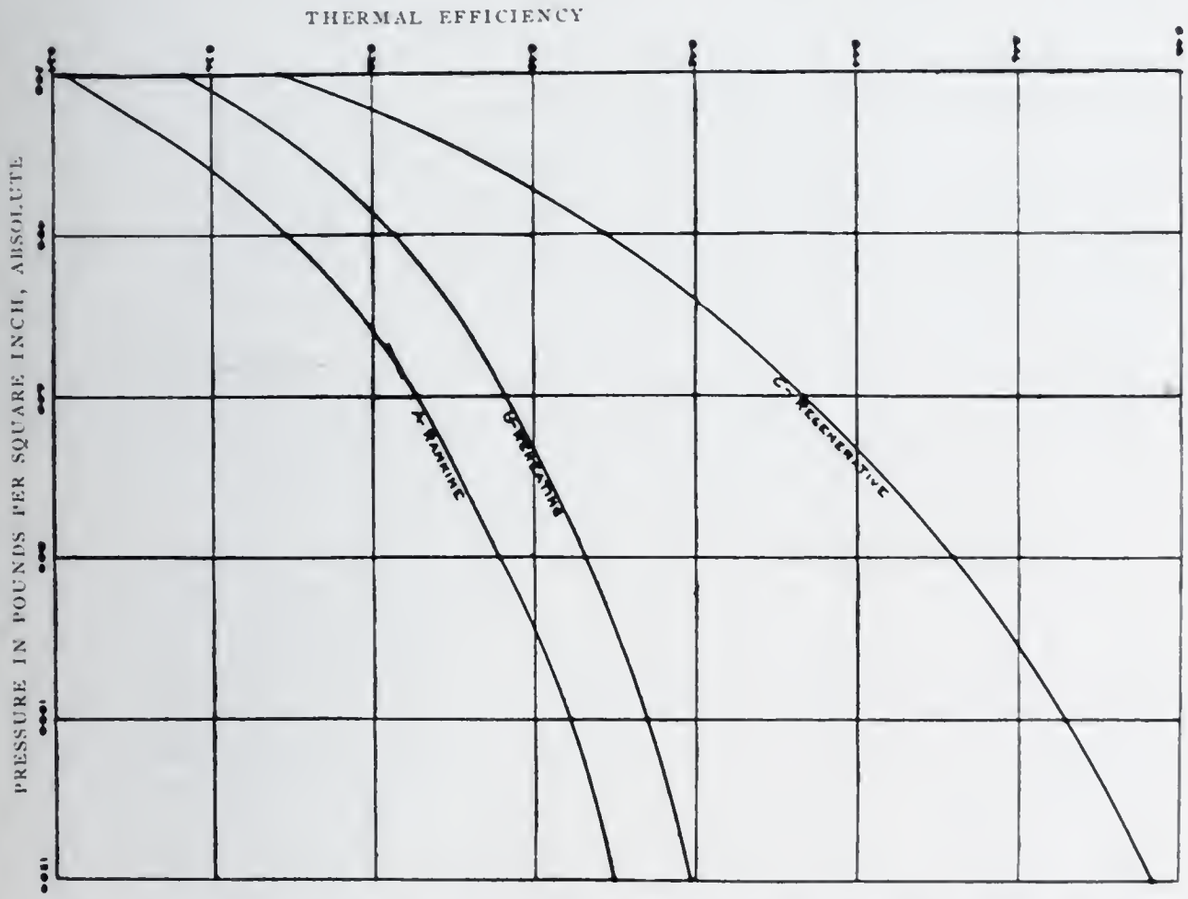

Fig. 16. Diagram Showing Efficiency with Reheating and Regeneration.

the means of materially improving the machine efficiency of the prime mover. Fig. 16 is a diagram showing efficiency with reheating and regeneration.

In order to approach the Carnot cycle as closely as possible, it is advisable to add heat to the steam at the highest possible temperatures, or to arrange the reheating so that the steam remains at a high stage of superheat as long as possible. The full benefit of the regenerative cycle can be obtained when the first bleeding occurs at the highest possible pressure and when the steam bled is saturated. From this it

would seem that the two cycles can not be utilized together to the best advantage. This, however, is not always the case, as the regenerative cycle improves the efficiency by transferring energy within the cycle, while the reheating process, properly used, takes energy from the outside and adds it to the cycle where it can do the most work. As regards the regenerative cycle, the objection has very often been expressed that it disturbs the proper relation between the stages, as the amount of steam bled from the stages may vary considerably. The following method, suggested by the writer, overcomes the above-mentioned objection and also makes it possible to utilize the regenerative as well as the reheating cycle to full advantage. In many power-plants there is recognized the advantage of having all auxiliaries driven electrically from a special turbine, which is usually called the house turbine. If the steam for the heating of the feed-water is bled from a number of stages of the house turbine, while the reheating cycle, or reheating the steam after it has passed a few stages and has lost some of its superheat, is applied only to the main turbine, the above-mentioned two cycles are fully utilized without interfering with each other and without taking any steam from the main turbine.

There are many ways of reheating the steam. The best known is to install a secondary superheater in the boiler setting and carry the steam from the turbine to the boiler and then back to the turbine again. This arrangement, however, has many disadvantages, as the pressure of the steam for reheating is considerably lower than that of the live steam. The pipes carrying the steam to the boiler and back must be, therefore, of a large size, and this complicates the installation. While there are now superheater designs on the market which give fairly constant temperature at different ratings, some fluctuations are liable to occur due to varying conditions in the furnace. The temperature drop of the steam in the turbine will, of course, vary, depending upon the load, etc. If the steam is sent back to the superheater installed in the boiler setting, we have a third variation, so that the total fluctuation temperature of the reheated steam may become very serious. There is another disadvantage of reheating the steam at the boiler which is generally not recognized. In most cases there is a considerable distance between the boiler and the turbine so that the piping to and from the boiler will contain an appreciable amount of steam, which will flow to the lower part of the turbine

even when the live steam is shut off by the turbine governor. This may cause overspeeding in case of sudden reduction of load unless a special governor is provided to control readmitting to the lower stages of the turbine the steam contained in the piping.

A much simpler arrangement is to reheat the steam in a separately fired superheater. It is generally believed that separately fired superheaters are inefficient. There are now on the market, however, separately fired superheaters which have water-tubes in the furnace ahead of the superheater; which can be operated with high furnace-gas temperatures; and which are very efficient, particularly in view of the fact that the steam to be heated is of comparatively low temperature and that, correspondingly, the temperature of the gas exit is also low. This would work out very satisfactorily in a plant where the auxiliaries are driven electrically from the main switchboard, and there is no exhaust steam available for reheating the water. The feed-water would then be preheated in the water surface of the separately fired superheater. This arrangement would give a high overall efficiency, and it would be less complicated, as the separately fired superheater could be located in the turbine room, and fired with either oil or gas; or with coal, in which case it would be located in the turbine room between the boiler and the turbine, with the furnace operated from the boiler room.

A still more convenient method of reheating steam is to have live steam from the boiler supply the necessary heat. This is particularly advantageous for the highest pressure. Naturally, the steam cannot be reheated to the initial temperature of the live steam, but this method has many other advantages which make it more desirable than others. It is not necessary to carry the steam back to the boiler room, as the reheater can be located near the turbine. The apparatus for reheating requires a comparatively small amount of heating surface, as the heat absorbed is the latent heat from the steam, which heat is very easily given up, and the coefficient of heat transmission is very high.

The most important advantage is the possibility of regulation. As mentioned above, the regulation is of considerable importance in connection with reheating of the steam. If reheating is accomplished with live steam, the regulation is very much facilitated, as all that is necessary is to regulate one valve admitting the live steam to the

heater. This is a very important factor in favor of reheating by live steam. Fig. 17 shows a reheater by live steam with a capacity of 200,000 pounds of low-pressure steam per hour.

In order to reheat the steam to a temperature higher than that of live saturated steam, it was suggested that two reheaters in series be used. The first increases the temperature of the exhaust steam to the

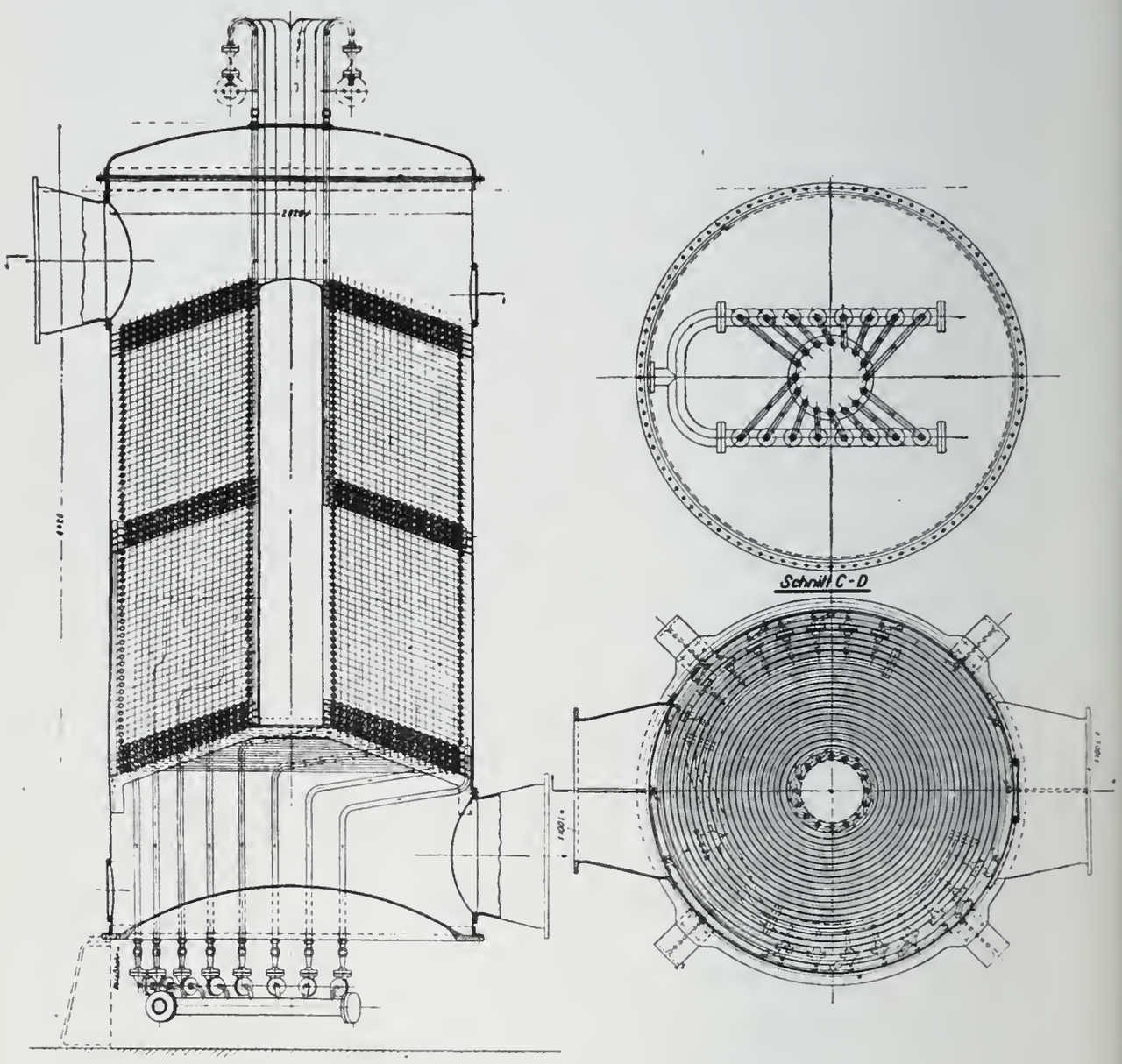

Fig. 17. Reheater Using Live Steam.

saturation temperature of the live steam, while in the second reheater superheated live steam is used, to increase further the temperature of the exhaust steam.

A rather unique method of reheating steam is to install in the boiler room a separate high-pressure boiler, the steam from which would be used only for reheating. In this case, except for the addi-

tional boiler, which must be of a considerably higher pressure than the main boiler, this arrangement has all the advantages above mentioned.

High-Pressure Back-Pressure. As stated in an earlier paragraph, the most startling characteristic of high-pressure steam is the advantage obtained by its use in prime movers exhausting against a back-pressure. By back-pressure I mean any exhaust pressure higher than that of the atmosphere. From the present back-pressure engines with the usual comparatively low initial pressure, we can expect only a dilatory development, for the reason that with the increasing back-pressure the greater part of the heat in the steam available for work is withdrawn. If, however, the initial steam is of a considerably higher pressure, then the heat withdrawn with exhaust steam is of less consequence. Table II shows the influence of the exhaust pressure and the advantages of high initial pressures:

TABLE II. EXHAUST TO 29-INCH VACUUM

Pressure	Superheat	Temperature	Ideal efficiency	Ratio compared with first line
200	218	600	0.3285	1.000
600	113	600	0.3730	1.135
900	68	600	0.3880	1.18
			Atmospheric exhaust	
200	218	600	0.1552	1.000
600	113	600	0.2600	1.675
900	68	600	0.2790	1.78

While the increase in ideal efficiency between 200 and 900 pounds initial pressure, at 29-inch vacuum, is 18 per cent., at the atmospheric exhaust it is 78 per cent., or nearly 4½ times as great. At 40 pounds back-pressure it is 192 per cent., or about 11 times as great.

The influence of back-pressure and the amount of power that can be obtained from 1000 kilograms (2200 pounds) of steam at different back-pressures is clearly shown in Table III:

TABLE III. POWER IN BRAKE HORSE-POWER OBTAINABLE FROM 1000 KILOGRAMS OF STEAM PER HOUR

Initial pressure	Saturated steam Back-pressure			Superheated steam Back-pressure		
	30	90	180	30	90	180
223	134	64	17.4	185.5	92.7	23.7
450	181	116	70	228	149	90
900	222	160	117	268	196	147

A study of the same relation between high pressure and back-pressure reveals the fact that at back-pressures which occur in practice—say up to from 100 to 160 pounds gage—the increase in the consumption of steam by a counter-pressure steam-engine per unit of energy (horse-power hour) will, at the live-steam pressure above 400 pounds, be only in direct ratio to the increase of the back-pressure. This ratio will gradually become less, or more favorable, with increasing initial pressure. This, however, applies only when the live-steam pressure is above 450 pounds. It is true for saturated, as well as for superheated steam. The benefit of high-pressure, back-pressure steam applies also to turbines, although with reciprocating engines it can be utilized more advantageously, due to the better efficiency at the higher pressures with the latter.

The ideal operation of a power-plant is attained, of course, when as much exhaust steam as possible is utilized. With the present average pressure this was found, however, to be of advantage only when the exhaust steam could be used at a comparatively low pressure; as, for instance, for heating or cooking or where a temperature between 200 and 250 degrees or a maximum of 300 degrees is sufficient. When exhaust of a higher temperature or pressure is required, it was not considered worth while to have the steam expanded in an engine, as the amount of work obtainable is comparatively low. Neither was it considered worth while to combine large power-stations with heating plants, as in central-heating plants a higher pressure—say at least 80 pounds—is usually required, because the steam must be carried over a long distance.

The combination of high pressure and back-pressure offers new possibilities to combined power and heating. The following example will show what may be expected from such combinations.

The Allegheny Steam Heating Company is building a plant in which there will be installed two boilers of 3000 horse-power each. If these boilers were to be built to operate at 800-pound pressure with 200 degrees of superheat, and the steam used in a turbine expanding to a high back-pressure, considerable power would be obtained without a material increase in the amount of coal burned. If the boilers were operated at 200 per cent. rating and the steam from the turbines exhausted at 100-pound back-pressure into the heating lines, the amount of power which would be generated would be about 22,000

horse-power, while the additional amount of coal burned would hardly be noticeable.

Take, as another example, a paper mill with four 500-horse-power boilers, of which three are usually in operation at 175 per cent. rating, with a steam pressure of 150 pounds per square inch. Sixty per cent. of the steam from these boilers is reduced to 75 pounds per square inch and used in the plant for the treatment of the paper in the processes of manufacture, and other uses. The other 40 per cent. of the steam is used to develop power, about 1500 kilowatts being required. If they installed boilers for a pressure of 600 pounds per square inch and 200 degrees of superheat, and generated the same amount of steam as they are now using in their process work, about 1900 kilowatts could be delivered in power by a turbine exhausting against a back-pressure of 75 pounds per square inch. This steam could then be used in the process work and considerable saving effected, as the 40 per cent. of the original amount of steam generated for power only would be no longer needed.

Valves and Pipe-Lines. Pipe-lines for high pressures must be designed so that any radical changes of direction are eliminated. Globe-valves are, therefore, not suitable for high-pressure boilers. Only gate-valves with unobstructed passages and parallel seats should be applied. It is absolutely necessary that the disk shall move freely, and that means that it must be pressed to the seat only by the pressure of the steam. When the disk, forcibly pressed between the seats, is inserted while cold, it expands more than the casing which is surrounded by cool air, and this causes undue stress on the casing. In spite of the fact that the casing may be strong enough to withstand this stress, it is very difficult (if possible at all) to withdraw the disk, even though the valve be provided with a by-pass.

The standard stuffing-boxes have proved to be insufficient for high pressure and high temperature. Also, the present packing material is insufficient for high superheat. It is claimed that self-lubricating metal packings with asbestos between the rings are giving satisfactory results.

In view of the fact that there is considerable difference in expansion between cast-steel on one side, and nickel or "Monel" metal on the other side, it is inadvisable to use these materials for very high pressures and superheat. Valve-seats of stainless or non-corroding

steel with the same coefficient of expansion as cast-steel are to be preferred.

In view of the fact that it takes considerable time to heat up a pipe-line to the temperature of high-pressure steam, considerable condensation occurs in the line before it is heated up. As trouble may be expected with traps in connection with high pressure and high superheat, a promising arrangement has been suggested for automatic draining of a high-pressure pipe-line.

For feeding of high-pressure boilers only, centrifugal pumps can be applied. By connecting the drain line into one of the stages of the pump where the pressure is lower than that in the pipe-line, the condensate is forced into the pump where it combines with the feed-water going to the boiler. The only disadvantage of this arrangement is that as the pressure in the pipe changes, the drain must be connected to different stages, so that the draining is not entirely automatic.

The most appropriate metal for valve bodies is acid electric-furnace steel. The better quality of acid electric steel is largely due to the maintenance of a reducing or non-oxidizing atmosphere within the furnace, resulting in a more nearly pure and completely de-gasified steel. Of considerable importance is also the proper and thorough annealing of the castings so that they may possess the best physical properties of which steel is capable. Knowledge of the critical points and transformations of annealing is required in order to secure the best physical properties.

Conclusion. In conclusion, I feel that this paper will have served a purpose, although it contains very little that is new, if it has placed the general question before you and aroused interest in the advantages, or otherwise, of increasing steam pressures and steam temperatures.

Those who have endeavored to reconcile all the various general requirements will have found that the problems of high pressure and high superheat are by no means simple, and that they are related primarily to boiler and turbine problems. Their proper solution is of such vital influence upon the total plant economy that they are worth serious consideration. I fully realize the limitations of high-pressure steam, but these limitations should be our milestones and not barriers.

DISCUSSION

Mr. G. G. Bell:* I have heard with much interest the paper by Mr. Broido on a number of questions which must receive consid-

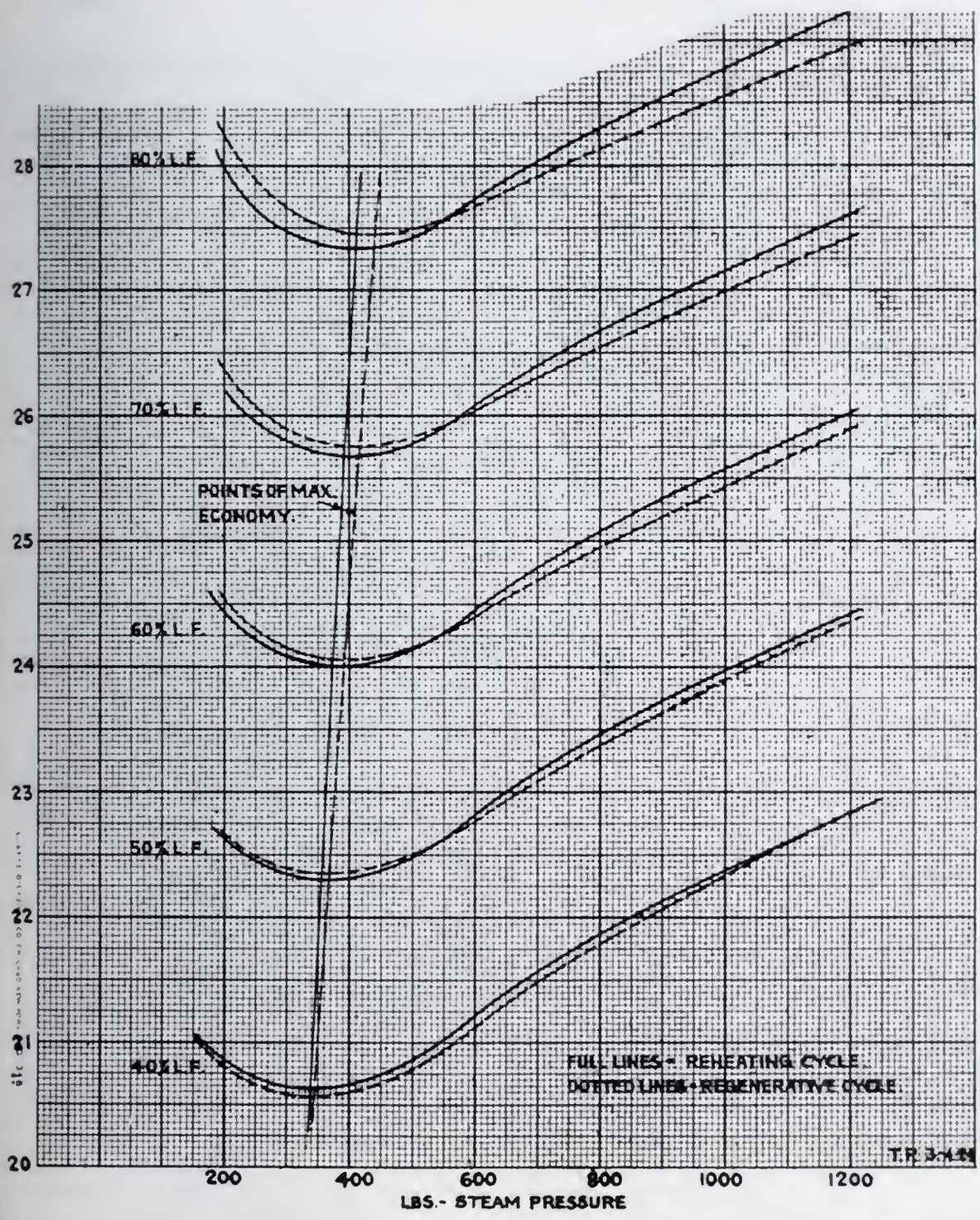

Fig. 18. Relation of Steam Pressure to Cost of Coal and Interest Charges for Regenerative and Reheating Cycles. Coal at $3 a Ton.

eration in designing plants for pressures higher than are in general use at the present time.

*Manager, Power Development, West Penn Power Co., Pittsburgh.

Probably the best study that has been made of the cost of producing power in high-pressure plants is that presented by C. F. Hirsh-

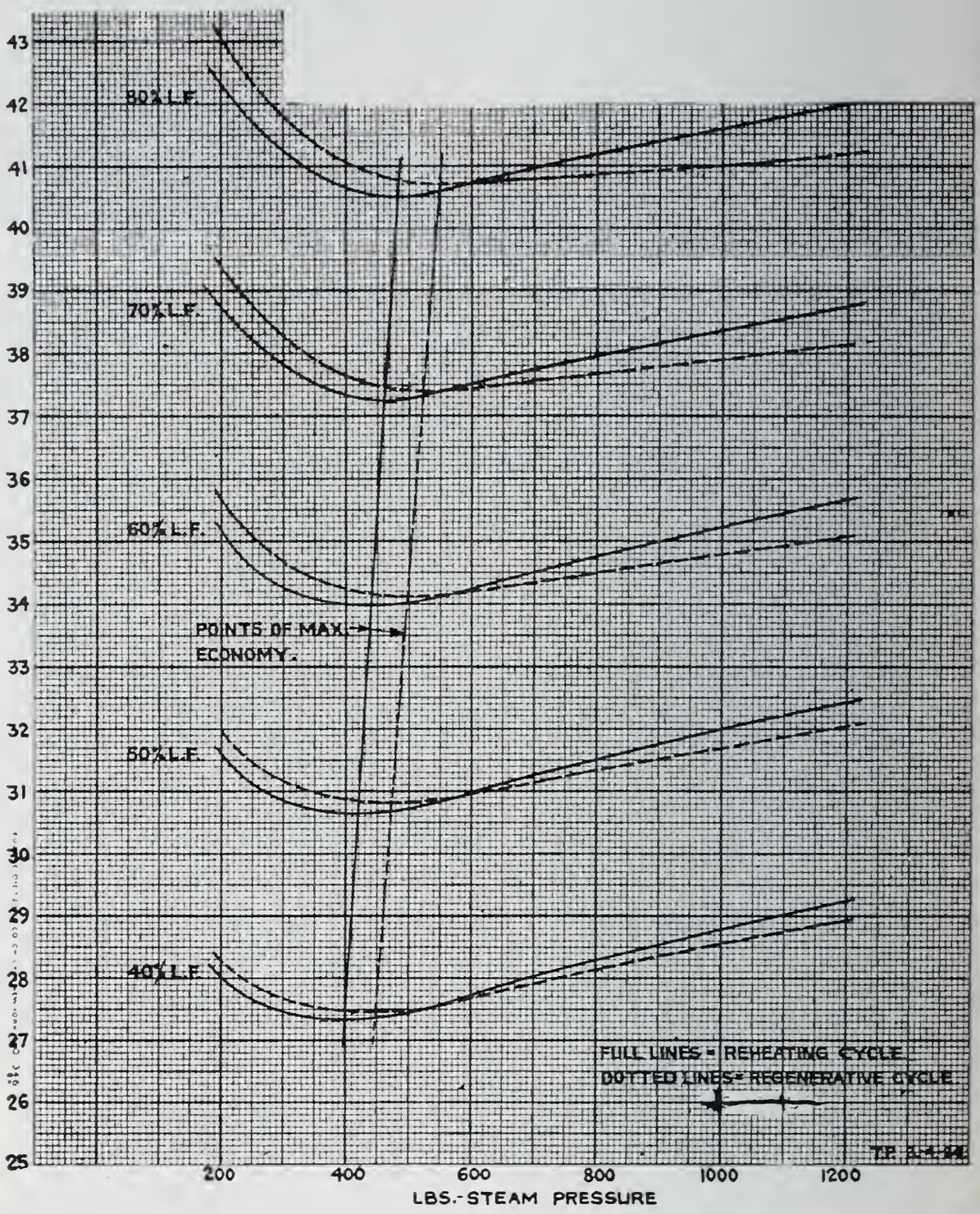

Fig. 19. Relation of Steam Pressure to Cost of Coal and Interest Charges for Regenerative and Reheating Cycles. Coal at $6 a Ton.

feld and F. O. Ellenwood before the American Society of Mechanical Engineers.*

I have prepared Fig. 18-20 showing the effect of the increased

*Mechanical Engineering, April 1924, v. 46, pp. 179-183, 225.

station cost and the better economy, on the annual charges for capital and for coal, for plants operated at load-factors of 40, 50, 60, 70, and 80 per cent., with coal at $3, $6, and $9 a ton. These costs do not include increase in maintenance for the higher pressures nor increased

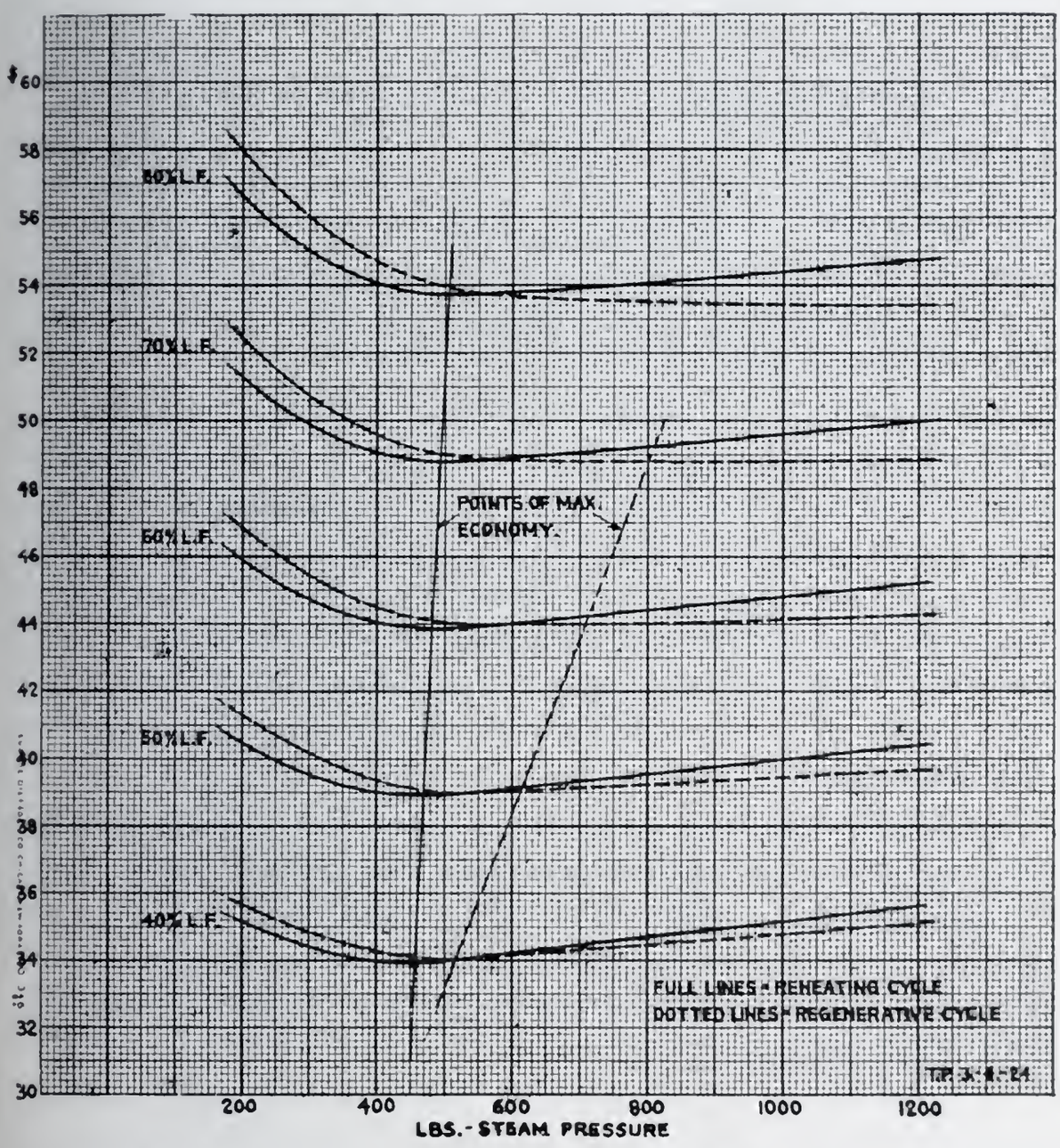

Fig. 20. Relation of Steam Pressure to Cost of Coal and Interest Charges for Regenerative and Reheating Cycles. Coal at $9 a Ton.

operating expenses, but we have calculated that all costs in excess of $100 per kilowatt shall bear annual interest at a rate of 23 per cent. in place of 13 per cent., which is used for the first $100. This increased figure will to a certain extent offset the difficulties resulting from the higher pressures. This study indicates that with $3 coal at

low load-factor, the economical pressure is about 340 pounds whether the station is designed for the reheating or regenerative cycle; whereas, for load-factors as high as 80 per cent. the economical steam pressure would increase to 410 pounds for the reheating cycle and 440 pounds for the regenerative cycle. This is based on the assumption that the feed-water is heated to the temperature of the saturated steam by steam extracted from the main unit. As the cost of coal increases, the advantages of the higher pressures increase. Thus, for $9 coal with 40 per cent. load-factor, 450 pounds is the economical point; whereas, for a load-factor of 80 per cent., 500 pounds is the economical point for the reheating cycle. For the regenerative cycle operated at 40 per cent. load-factor the economical pressure is 520 pounds. At 80 per cent., the costs are very nearly the same between 600 and 1200 pounds.

Until further information is available from plants actually operating at higher pressures, it is not probable that we would make any substantial change in the plants which we are designing at the present time, except perhaps to raise the maximum boiler pressure from 350 to 400 pounds or slightly higher, which is the maximum pressure for which the type of boiler we are using at the present time can be designed. This increased strength of the boiler would allow further deterioration of it before the capacity and efficiency of the plant are reduced on account of corrosion.

I would have been interested in having Mr. Broido include a table which would show the advantage of varying pressures with a constant maximum temperature. This represents conditions more nearly as they exist at the present time, as we are all designing our later major stations for approximately the same ultimate temperature, but varying pressures.

Increasing the superheat to the limit permissible will probably result in a larger return on the investment than will increasing the pressure, as the gain due to greater mechanical efficiency of the machine—on account of a lower friction of the superheated vapor than that of the saturated vapor—overbalances the gain due to higher pressure.

In designing machines for high temperatures it is advisable that there be as few fits as possible, and that the male portion of the fit be exposed to a higher temperature than the female portion. The num-

ber of shrunk fits should be reduced to a minimum, so there will be no tendency for parts subject to varying temperature to become loose.

I am interested in the Venturi type of feed-water heater outlined by Mr. Broido, and would like to know for what ranges in steam pressure it can be designed and what would be the effect of change in the load.

With regard to extreme high-pressure boilers, I understand that at Weymouth station they do not expect the safety-valves to blow; that each safety-valve has a pilot safety-valve, which is expected to give warning of an unusual rise in pressure, and the boiler pressure be reduced before it is necessary for the safety-valves to open. A gate-valve is located between the pilot-valve and the drum, so that it can be shut off and repaired while the boiler is in service.

In running any plant at high ratings or under high-pressure conditions, an exceptionally high class of boiler water is necessary. Even with evaporated water it is possible to get fairly high concentrations in the boiler, as it is practically impossible to keep the condensers absolutely tight. The water in the various boilers, therefore, has to be analyzed at regular intervals, and the boilers blown down or chemicals added to take care of the scale-forming matter in the water.

For the past six months we have been using the method of tests arrived at by Dr. R. E. Hall, Pittsburgh Experiment Station of the United States Bureau of Mines; Carl Fischer, Mesta Machine Company; and George W. Smith, Hagan Corporation.* Previous to that time we were not able to keep our boilers entirely free from scale, it being necessary to turbine out a very thin layer of scale at least once every six to twelve months; but the indications are that with the methods now in use even this thin scale will be eliminated.

High velocities in the superheater may prevent the formation of a deposit in the superheater tubes; but any moisture carried over from the boiler will be evaporated in the superheater and the solids will be carried with the steam and deposited in the steam-piping and eventually pass through the turbines to the condenser. This is troublesome, especially with small governor valves, and undoubtedly has a damaging effect on the turbine blades; and anything that will tend to the

*Iron and Steel Engineer, June 1924, v. 1, pp. 312-327.

elimination of water being carried out with the steam should materially reduce turbine maintenance.

I would like to ask Mr. Broido whether the ball-and-socket joints are always placed outside of the boiler; and, if they are placed inside, whether there is any difficulty in remaking the joints.

The Society is to be congratulated upon having a paper so comprehensive as that of Mr. Broido's; especially one dealing with a matter that is so interesting.

MR. L. W. HELLER:* There is one point brought out in the paper which perhaps is not fully recognized, but which, I think, is very important. That is, the fact that the high-pressure engine and the high-pressure turbine operating non-condensing have very different characteristics. The point is stressed that high-pressure steam in an industrial plant—especially one using steam for a combination load of power, heat, and process work—is particularly advantageous.

Mr. Bell brought up one point, which, I think, is of particular importance in the design of high-pressure boilers, and that is the matter of regulation, as Mr. Broido emphasized the fact that boilers need large steam-drums.

With the future development of fuel burning—that is with fuel in gaseous, liquid or pulverized form—the control is very easy. The fuel supply can be cut off and the steaming cut off almost instantaneously. Even with a pulverized-coal unit with refractory walls, the water and coal can be cut off at practically the same time and no serious trouble, due to lowering of the water level, will result.

With the future development of water-cooled walls, this control and regulation of water-supply and fuel supply will probably be made still easier. Without doubt, the future furnace will use highly preheated air with a considerable amount of water cooling in the furnace walls, or make use of furnace walls for superheating by the use of "radiant-type" superheating—a type which Mr. Broido did not mention.

Just one other point in the comparison of the high-pressure engine plant and the high-pressure turbine plant operating under the same conditions—what will the comparison be when all factors, such as the

*General Superintendent, Power-Stations, Duquesne Light Co., Pittsburgh.

investment in buildings, operating labor, maintenance and lubrication costs, are considered?

In the design of the steam-heating plant of the Allegheny County Steam Heating Company which was mentioned, and in which very large boilers of 3300 horse-power are installed, building space and real estate are of prime importance; the heating load is largely a winter load.

Still further, in the consideration of the design of the central-heating plant, the load-factor determines to a great extent the character of the plant design and must be given full consideration when studying the investment which must be made if high-pressure boilers, and equipment which has not been developed commercially, are to be installed.

Mr. L. C. Frohrieb, *Chairman*:* Mr. Broido's reference to the regenerative system recalls to my mind two engines thus equipped with which I am familiar, and which, as far as I know, are the only large engines in this country fitted with this system. They are both quadruple expansion, one direct connected to a pumping engine and the other to a two-stage air-compressor, and were built by the Nordberg Manufacturing Company, of Milwaukee. These machines still hold the record for economy.

The steam to the engine driving the air-compressor is at 250 pounds pressure with no superheat. The feed-water is heated by a series of five heaters, the first receiving its steam from the main exhaust before entering the condenser; the second, from steam tapped direct from the low-pressure cylinder; the third, from the third receiver; the fourth, from the second receiver; and the fifth, from the first receiver.

The initial pressures in the various cylinders are high. The final temperature of the feed-water is 335 degrees F. and a test showed that the heat consumed by the engine per indicated horse-power hour was 10,157 B.t.u. This is the highest economy so far obtained from any steam-engine.

Mr. B. N. Broido: The reason why the table was made up only for saturated steam is because we have not, as yet, reliable data for

*President, Federal Engineering Co., Pittsburgh.

superheated steam at high temperatures. Tests are now being made at Harvard University which we hope will give us a little more correct data.

The Venturi type of feed-water heater may be designed for any pressure, particularly in connection with large units or where a large amount of water is to be fed into the boilers. A pressure difference between the steam and water of 10 pounds at high stages, and five pounds in the lower stages, would be sufficient, particularly when the surface contact between the steam and water would be large enough. The fluctuations of load I mentioned in the paper (and Fig. 8) show how to take care of it by varying the area through which the water flows so that its velocity and pressure are also changed.

I fully realize that not every plant will require the use of an accumulator. Mr. Bell is entirely correct that in base plants with pulverized fuel where regulation is easy, an accumulator would not be required. I mentioned only that there are difficulties where load variations may occur, and how these difficulties can be overcome by arranging an accumulator.

It is true that with the high velocity of steam in the superheater any scale or impurities will be carried over with the steam. There is, however, enough space in the piping where the sediment can accumulate before entering the prime mover. For that reason I think high steam velocity in the superheater units is desirable.

Mr. Heller says I did not mention the "radiant-type" superheater. I did not mention this type of superheater because no superheater directly exposed to the furnace gases will ever be a success. There is no material commercially available for superheaters at a reasonable price which would withstand the fluctuations of the high temperature without being protected by a water-cooled surface. There is on the market one superheater which I know, which will probably be the only one ever successful, and that is the radiant superheater behind water-cooled tubes. That is the only radiant superheater that will survive.

SOME NOTES ON FOUNDATIONS*

By Charles R. Gow†

While engineering in general has tended more and more to approximate an exact science and while most of its problems are now susceptible of solution within close limits of agreement, the subject of design and treatment of foundations has not yet reached the stage where there appears to be even a semblance of unanimity among the experts.

Some progress, it is true, is now promised along the lines of standardizing various classifications of soils and allowable loading thereon, but conflicting theories and assumptions of long standing do not yield readily to new suggestions, even when predicated upon careful research and extensive experience on the part of others. A survey of the vagaries of modern practice as it affects the design of foundations for structures leads one to the belief that either there is an unjustifiable and enormous economic waste in current foundation practice, or very grave chances are frequently taken by the adoption of extremely liberal units and assumptions. In view of the fact that there are comparatively few foundation failures involving serious consequences, the evidence would seem to be in favor of the first hypothesis.

Every thoughtful engineer will agree that there can be no more important consideration in the design and execution of construction undertakings than that involved in the selection and installing of an adequate foundation; but for some unaccountable reason there is no more neglected field of study and inquiry in the entire range of his activities. It is with a desire to stimulate some further interest in the subject, and an enlightened discussion along related lines, that this paper has been prepared.

The engineer's service to his client should really begin with the selection of the site. In purely engineering construction this frequently occurs. In the selection of sites for buildings and similar structures, however, the engineer is in most cases not consulted. As a result, locations which from superficial appearances are ideal for their intended purposes may upon subsequent examination be found to be economically prohibitive because of the expense incident to the secur-

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†Consulting Engineer, Boston.

ing of adequate and proper foundations. Strictly speaking, it would seem that the cost of the necessary foundations over and above that for a more favorable location should be added to the cost of land in making comparisons of their relative purchase prices. The usual practice, however, is to treat the real-estate problem as an independent one and to compare the land prices alone in making the choice between the various sites that are available. Money expended for preliminary test pits or borings will ordinarily prove to be amply justified. Liberality in this direction will frequently be found to return large dividends in the form of information which is absolutely essential to an intelligent and safe design.

On the other hand, unless the borings are made by competent parties and correctly interpreted by experienced persons, the results may be fully as unsatisfactory as if arbitrary assumptions alone had been relied upon. Samples of soil which are recovered from the returning water of wash borings may be entirely misleading as to the character of the material penetrated. The action of the water in separating the coarse and fine ingredients often renders it extremely difficult to recognize the true nature of the deposit in question. For example, a cemented mixture of clay, sand, and gravel, when tested in this fashion, will appear to be a clean, loose sand and gravel, the clayey material having been washed away or otherwise held in suspension in the wash water itself. It is essential, if misleading results are to be avoided, that samples should be secured in their natural state by means of a suitable recovery spoon, driven somewhat in advance of the point to which the washing process has progressed. It is likewise difficult without a considerable degree of experience to distinguish between some forms of artificial filling and natural deposits of the same material. Similarly in many instances silt, and in other cases extremely fine sand, may easily be mistaken for clay. These possibilities indicate the necessity of selecting for work of this nature only those whose standing and experience in this particular field of endeavor are well recognized.

Where it is desired to determine the location of the underlying ledge, dependence upon wash borings alone may prove to be unreliable, for, while they may usually be depended upon to determine when rock is encountered, it is not easily possible to distinguish between ledge rock and large boulders. Frequently blasting may be

resorted to for the purpose of removing boulders, and with soils of glacial origin, a small sample or chip from the surface of the rock will indicate whether it is of a character similar to the known ledge rock of that particular locality, in which case the fair assumption is that ledge has been encountered. In case the sample is of a type foreign to the territory, it may be assumed to be from a boulder, but the latter test is of a negative character and does not afford the satisfactory and conclusive evidence which is obtained by the use of core borings.

In case of very important structures test borings should, if possible, be supplemented by one or more test pits carried to the proposed footing level. Such a pit will not only afford a more definite basis of information respecting the general character of the subsoil, but will also develop, better than any other method, the extent and level of the ground water and the particular behavior of the various strata of soil to be penetrated. A vast field of undeveloped usefulness still awaits the engineering profession of this country in the nature of an intelligent education in and the practical application of the science of making and interpreting test borings.

In the aggregate, enormous sums of money are lost or wasted yearly in this country, and much needless litigation precipitated as a consequence of inadequate or misleading preliminary information with respect to the underground conditions affecting construction work. Assuming that a competent determination has been made of the character and arrangement of the subsurface conditions, the next problem presented is that of properly appraising the value of the several available strata with regard to their capacity to carry the proposed loads.

Familiarity with a certain type of soil common to a given locality probably warrants an assumption of its value as a bearing medium, based upon its known behavior in previous instances. In the absence of such knowledge, however, an actual experimental test of its carrying capacity is highly desirable. Current methods employed in conducting soil-loading tests vary greatly. Probably the results usually obtained from experimental tests seldom correspond with the actual supporting capacity of the material under subsequent conditions of permanent loading, because it is somewhat difficult to reproduce with exactness in experimental form all of the attending conditions of final use.

Unless provision be made to prevent the lateral displacement and escape of the soil immediately beneath the area of application of the pressure, a test is of little value. Likewise if ground water be permitted to percolate upward through the soil during the period of testing, the behavior of the material under loading may not correspond even approximately with that found under conditions of normal hydrostatic head. In a somewhat recent instance, the writer was engaged in sinking some concrete caissons for supporting some rather heavy building-column loads. The work was executed under compressed air and the material encountered was an extremely tough mixture of clay and sand containing a moderate amount of gravel. Under the dry conditions imposed by the pneumatic process, this soil could be excavated only with the greatest difficulty. A pick in the hands of a husky laborer made only a slight impression on its surface. Before filling the first caisson with concrete, however, it was required that a loading test should be applied upon the soil and, in order to comply, it was necessary to remove the air-lock and subject the material to atmospheric conditions. While the testing facilities were being installed, a small amount of seepage water percolated through the soil, but was easily removed by occasional bailing. When, however, the test load was applied, it was found that the vertical timber by means of which the load was imposed settled readily under an insignificant weight and the material flowed out freely from under the loading plate. A somewhat better, but still decidedly unsatisfactory, result was obtained by repeating the experiment in the case of another footing, permitting the water to rise to its normal level before applying the load.

It was then determined to adopt a method of testing which the writer has used and recommended for some years and which attempts to approximate more nearly the actual conditions which exist in the completed structure. A cast-iron plate two feet square was bedded in cement upon the soil while it was still subject to compressed-air conditions. A layer of concrete was then deposited over the entire exposed area of the caisson base, leaving an open well over the cast-iron plate, the edges of which were heavily greased so as to avoid adhesion to the concrete. (See Fig. 1.) When the concrete had attained a satisfactory set, the air was taken off, the lock removed, and the test timber lowered so as to rest upon the cast-iron plate and thus distribute its load over the four square feet of soil area under it. Before applying

the load, the caisson was flooded with water up to normal ground-water level for the purpose of creating a set of conditions resembling as nearly as possible those which were expected ultimately to obtain. With no opportunity afforded for the loaded soil to escape laterally as in the former test, a loading of 10 tons per square foot produced a settlement of less than one inch. It was determined to adopt a working load of five tons per square foot. After the foundations had been

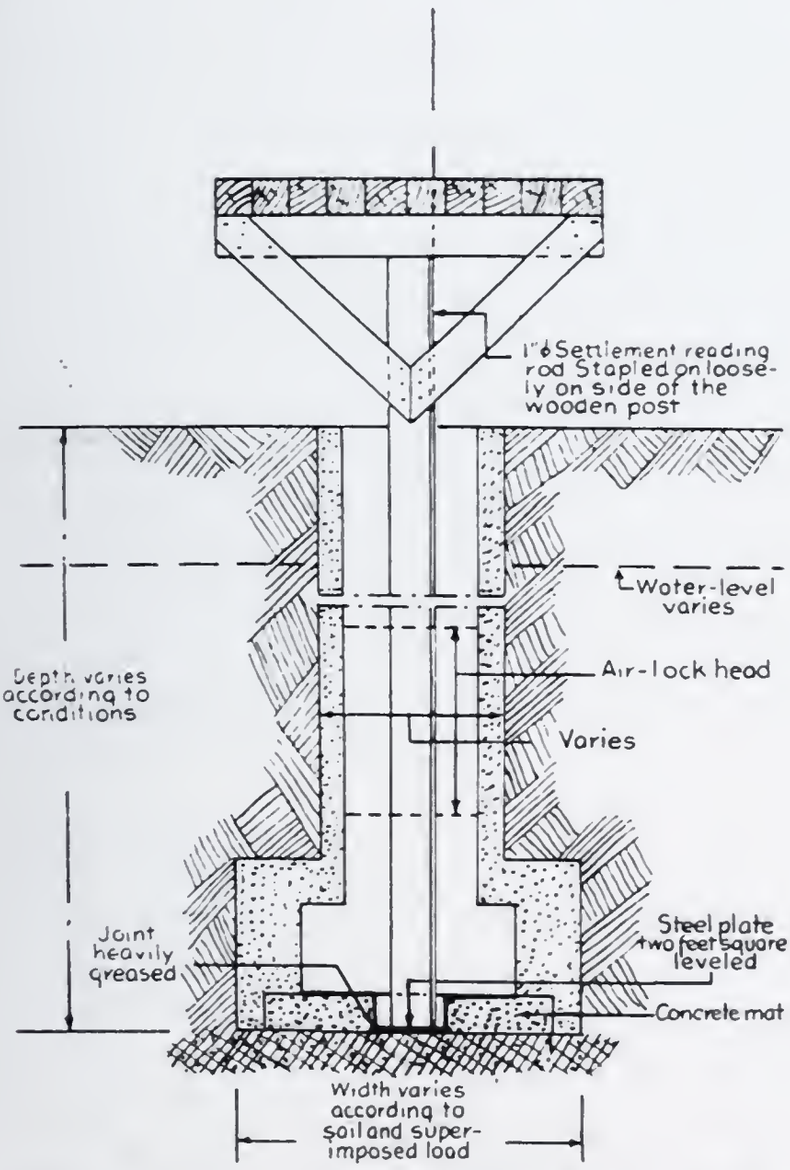

Fig. 1. Method of Applying Test Load to Soils.

completed, two additional stories were added to the building, bringing the final loading up to six tons per square foot and no observable settlement has resulted. It is a well recognized phenomenon that any stratum of sand or gravel will show a much smaller resistance under test loads where water is allowed to percolate upward during the testing period. It is essential, therefore, that wherever ground water

does tend to enter the testing pit through the soil, its movement should be counteracted by producing a state of hydrostatic equilibrium.

When structures are to be built upon earthy soils, it is not to be expected that subsequent settlement can be entirely eliminated. Wherever a concentrated pressure is applied at a given spot upon any soil there is usually an initial "take-up," so to speak, which results in some consolidation of the material immediately under the footing and extends downward and outward in the form of an enlarged bulb frequently referred to as the "bulb of pressure." During the process of producing this reaction in the soil there is apt to be some slight readjustment in the level of the footing itself unless extremely low unit pressures are adopted.

It seems highly probable that practically all structures resting upon soil settle more or less during the successive stages of applying their load and that the amount of such settlement will vary from a small fraction of an inch to one or two inches, depending upon the character of the material and the unit loading employed. Provided the soil is homogeneous in nature and the unit loading is uniform for the several footings, no consequences of an objectionable nature will result even though the movement be of a substantial amount. The writer has known of extreme instances in which general settlements of as much as four or five inches have occurred without even coming to the attention of the owners or occupants of the building and with an entire absence of visible indications.

When, however, the character of the material varies in different sections of the lot, this feature calls for a somewhat more careful consideration. The most extreme case, of course, is that in which part of the area is composed of ledge rock and the remainder of soil. Under such circumstances unit loading values somewhat below those usually employed should be adopted for those footings which rest upon the soil. By this means, subsequent settlement will be reduced in amount and the variations in the relative movements of the different portions of the structure will be minimized. The same precautions, but to a lesser degree, will be found desirable when variations of different soils are encountered in the same lot.

The soils commonly met with in construction practice may be classified roughly into filling, peat, silt, sand, gravel, and clay. There are also, of course, various combinations of these materials.

By filling is meant material that has been artificially transported to the new location. If in the process of its transportation it becomes mixed with other kinds of soil or of varying degrees of foreign substances, it will always be easy subsequently to distinguish it from natural deposits of the same type. When, however, perfectly clean excavated material is taken from one locality and deposited in another it may not be so easy readily to identify it in subsequent years as a fill deposit. In the case of stratified materials, the lack of stratification may give the distinguishing clue, while other soils which in their natural deposit show vertical faces of homogeneous color may in the filled state present a slightly mottled appearance. It remains a fact, however, that filled material is frequently a most difficult thing to identify with certainty. Providing it does not overlie a readily compressible material and does not contain in its own body some perishable substance such as paper, wood, metal or organic matter, a fill which has been in place for a considerable period may frequently be relied upon to carry substantial loads. It is not likely to support as great a load as it did in its natural position unless in the meanwhile it has been subjected to a considerable pressure from some superimposed weight, such as piles of lumber, coal or ore. Usually such material may be depended upon to support safely light structures of relative unimportance. Conservative practice usually regards filled material as an unsuitable medium for the permanent support of engineering structures.

Peat is a name given to masses of decomposed vegetation usually intermingled with more or less silt or humus. While peat beds are ordinarily found below the ground-water level of the adjacent territory, the evidence of former vegetation which they present, indicates that subsidence of the land in the vicinity has at some time taken place since plant life must originally have had access to light and air. Since peat is highly compressible in character because of its organic nature and porous structure it constitutes an entirely undesirable foundation medium. Nor is the fact at all helpful that it may have been in its present position for centuries and subjected to the consolidation process during this period. Loads even of moderate amounts overlying peat strata are almost sure to experience some settlement as a consequence of their further compression.

The term silt is sometimes confounded with peat, but neverthe-

less there is a marked distinction between the two substances. Silt is composed of fine material—either sand, clay, loam, or organic matter—which has been carried in suspension in the waters of the stream and subsequently deposited by sedimentary action in the more quiet areas where the velocity of the flowing water has been reduced or arrested. The terms mud and silt are frequently used as synonymous; but, strictly speaking, the former term, while properly applying to the material which we call silt, has a much wider application and may properly be used to describe all slimy mixtures of earth and water. The composition of the silts encountered in various localities may vary greatly, depending upon the preponderance of one of many different materials of which it may be composed. When fine sand constitutes the major ingredient, a silt may offer a very considerable degree of resistance to compression and even support rather substantial superimposed loads. Most silts, however, contain large amounts of organic matter together with admixtures of clay, and not infrequently of peat, which give them highly compressive qualities and thus invalidate them for possible use in supporting heavy loads.

The mistake is sometimes made of assuming that because a layer of peat and silt has been subjected for a long period to the weight of a considerable overburden of fill, it may be considered to have developed its final degree of compression and hence be capable of supporting any reasonable additional load. To realize the fallacy of such an assumption one has but to consider the sequence of events which follow the initial deposit of the silty substance. In its first state it is in the form of a semi-fluid possessing practically no supporting power. Under the influence of its own weight, and later, under the pressure of the superimposed filling, the layer of silt or peat is compressed to a point where a resistance against further compression is developed just sufficient to counteract the weight of the load which causes the compression. There then ensues a condition of exact equilibrium between the load and the resistance against further compression. At any subsequent period if an additional load is applied there will, of necessity, take place a further compression of the silty material sufficient in amount to supply the added resistance needed to support the new load. It may thus be expected, and it usually will be found, that every attempt to utilize this material for foundation purposes will be likely to result in very appreciable settlement of the structure.

There is one aspect of this situation, however, which may at times be helpful to the engineer. If a layer of peat or silt has carried the weight of a substantial fill or other load for a sufficient period of time to permit the consolidation of the former to the point of equilibrium, then it will probably continue indefinitely to support such a loading, whether it remains in the form of filling or is replaced by some other matter of no greater weight. Suppose, for example, that an area way is to be constructed extending from the basement of a building under the sidewalk and that a layer of peat or of silt exists somewhere below that level. The substitution of the area opening, in place of the former sidewalk fill which it replaces, will reduce rather than increase the load subsequently to be carried by the underlying soil; and, provided it has previously been compressed to a point of equilibrium with the overlying load, there should be no question as to its capacity safely to carry the new load of a lesser amount. Generally speaking, however, it cannot be said that either peat or silt is a satisfactory soil upon which to support the weight of a structure, and, aside from the minor exceptions above noted, no conservative engineer will assume the serious risk which is involved in utilizing these materials in carrying foundation loads.

Aside from ledge rock, sand and gravel are usually recognized as the most satisfactory substances upon which to impose foundation loads. Both sand and gravel are composed of fragments of rock and vary only in the size of their particles. Since they are formed solely from the breaking up or pulverizing of rock masses, it stands to reason that the size of the individual grains is the sole distinction between the finest of the sands and the coarsest of the gravels. Viewed through a microscope, the fine sands with grains scarcely distinguishable to the naked eye resemble a nest of small boulders resting upon each other. Since they are of exactly similar physical composition and structural arrangement, there is no reason to expect that sand and gravel will behave differently under conditions of loading. It is customary, however, to assign higher values to gravel than to sand and to give to coarse-grained sands a greater allowance than that permitted in the case of fine sands. Frequently a substantial distinction is made between dry and wet sand with respect to their respective bearing values. It is at such points that marked conflicts of opinion arise between engineers, who in the light of their experience should be expected to speak authoritatively.

After more than thirty years of intimate contact with and observation of the behavior of soils under conditions of loading, it is the writer's conviction that there is very little, if any, difference between the behavior of sands and that of gravels when subjected to the same unit pressure from actual structures founded upon them. To many this assertion may appear unwarranted in view of the known variation observed in results obtained from actual test loadings. However, in the great majority of these cases the difference may be accounted for by faulty methods of conducting the tests as previously referred to herein under that subject. It is entirely probable that sand, and especially fine sand, will be displaced laterally under pressure more readily than will a coarser grained material. Likewise, upward infiltration of water through fine sand during the testing period will undoubtedly tend to render it far more unstable under pressure than in the case of the more open and porous coarse sands and gravels. Assuming, on the other hand, that lateral displacement is prevented and that there is a balanced hydrostatic head of ground water, it would be necessary to overcome the same identical forces in either case in order to produce settlement, and it is difficult to believe that a mere difference in size of grains will produce any marked variation in the results.

The foregoing discussion leads us to consideration of that material known as "quicksand." Quicksand is, in reality, not a material; it is, rather, a condition of a material. Under normal conditions of ground-water level the substance which we recognize as quicksand is as stable as and possesses all of the characteristics of a dry fine sand. The trouble is that we never see it in its natural state but only, when in the process of excavating and pumping, we artificially produce an unbalanced hydrostatic head which in turn induces a more or less violent upward flow of water through the fine sand; thus, for the time being, destroying its stability and creating a semi-fluid substance which seems to lack any supporting power.

The action which produces this instability is easily understood. In a normal state, the individual grains of sand rest one upon the other, and in order to move them in any direction it is necessary to overcome the friction due to this contact, which from a comparative standpoint is considerable, especially when they support the weight of a superimposed load. Any flow of water through the voids, however, reduces the amount of this friction between particles by the amount

which it tends to lift the individual grains. The greater the hydrostatic pressure which causes the flow, the more the particles of sand are lifted from one another until finally all friction between the grains is destroyed and they are free to move in any direction under the influence of insignificant pressures. In such a state, the sand yields readily under the weight of a workman and he sinks into the material. If now the trench or pit is allowed to fill with water to its normal level, the flow through the sand ceases and it assumes its natural condition which is that characteristic of any fine sand. As a matter of fact, given a sufficient volume and velocity of water, any granular material, regardless of the size of its particles, may be made to act like "quicksand." It has been the practice of the writer for many years to disregard the "quickness" of sand as an indication having any bearing whatever upon its capacity to carry loads and to assign to it the same foundation value as in the case of other sands. There are many such foundations serving their purpose to-day without any evidence of settlement or other movement.

Of course, it must always be understood that where structures are founded upon or over this general type of material there will always be danger of subsequent undermining and consequent settlement in case future adjacent excavations are carried to levels below the footings already in place. Unless special precautions are taken to prevent an inflow of water into such an excavated opening, there is likely to be some movement of the sand itself carried in a lateral direction from under the existing foundations, thus leaving a void which must be filled by settlement from above. Many authorities contend that the mere lowering of the ground-water level by artificial means will of itself produce a settlement of the surrounding ground, whether or not the sand is withdrawn from the material. The writer does not believe that there is any basis for such a theory. Ground water which is contained in a body of sand or gravel merely fills the voids of the material. The particles constituting the mass rest upon one another in close contact. In fact, it is a common practice to consolidate dry, loose sand or gravel by puddling or flooding it with water. If then, this water which can fill only the void spaces is withdrawn, the result will be to leave the several particles just as they previously existed and we have the voids filled with air instead of water.

In frequent instances, driven wells drawing water from saturated

sand beds are operated continuously for years without affecting in the slightest degree the surface level about them, although the water-level is repeatedly drawn down many feet below its normal elevation. In all cases where settlement or subsidence of adjacent ground is observed, following the withdrawal of ground water from the surrounding territory, it may be set down as reasonably certain that a substantial amount of sand has been carried with the water to the pumps and that it is the removal of the sand and not the removal of water which has caused the settlement.

There is great variation of opinion respecting the safe supporting power of sand and gravel. Allowances of from one to six tons per square foot are met with in the customary practice of different authorities and in the stipulations of local ordinances. In the judgment of the writer, the maximum figure of six tons is not excessive for any form of these materials, although it may possibly be found that this allowance will result in a somewhat greater settlement in some instances than in others. In none is this settlement likely to be serious in amount. It is usual to find that the major part of such settlement will occur as the dead load is applied and that the earlier loads produce the greater increments of compression. With structures founded upon sand and gravel, it is seldom, indeed, that motion of this character takes place subsequent to their completion.

In connection with these statements a note of caution should, perhaps, be sounded. Many forms of fine sand contain admixtures of clay or silt, and in these cases the behavior of the soil under loading may resemble more nearly that of the latter substance rather than that of the former. The observations so far recorded relate solely to clean sand or gravel free from plastic ingredients.

Clays are formed as a result of the disintegration of feldspathic rocks, and possess characteristics entirely dissimilar to those of sand or gravel. The material varies greatly in its relative hardness and moisture content, and these two conditions appear to have a direct relation to one another.

The moisture content of clay may sometimes be found to run as high as 30 per cent. by volume in the case of very soft clays, and, as this moisture is driven off by heat, it will be found that the material reduces a like amount in volume and becomes exceedingly hard in texture. The great variation found in nature is apparently due to dif-

ference in the elimination of moisture content occasioned either by the application of heat or pressure or perhaps of both.

Clays are either residual, as when found in place, or transported, as we find them throughout the great area of the northeastern section of the country, the surface of which is of glacial origin and formation. Residual clays are merely masses of decomposed ledge remaining in their original position but transformed in physical character as a consequence of chemical changes which they have undergone. Such deposits are common throughout the southeastern section of the country. They tend to merge into the underlying ledge as successive depths are uncovered, and masses of the original rock in undecomposed form are frequently encountered in isolated pockets.

The transported clays, on the other hand, such as are encountered quite generally in the territory east of the Mississippi and north of the Ohio River, have in general been carried from a distance by glacial action and deposited through water as the ice sheet melted and retreated. These clays are usually of a bluish-gray color and have an extremely fine texture. The individual particles of clay are too fine to be seen by the naked eye and may be found as small as 1/25,000 of an inch in diameter. When these clays are exposed to atmospheric action for long periods, oxidation takes place, producing a yellowish or brownish color as a consequence of the iron oxid which is developed. The latter substance acts as a cementing binder and we find the yellow clays to be much harder in character than the original deposit. It seems probable that the weight of the advancing and retreating glacier may frequently have rested upon clay beds previously deposited. This may readily account for the fact that some clays are extremely hard and friable while others are almost semi-fluid.

It has been the writer's practice to classify all clays roughly into three groups—soft clay, or that which can be easily spaded; medium clay, or that which can be spaded only with considerable difficulty; and hard clay, which requires some form of picking in order to loosen it before spading. The hard clays, generally speaking, will safely support loads up to five tons per square foot, and in the case of hard yellow clay even six tons. Medium clays will usually be found safe under loads of four tons per square foot, while the soft clays, with rare exceptions, will show relatively little settlement if limited to loads of from two to three tons per square foot.

The quality of plasticity which is a distinguishable feature of clay renders it peculiarly susceptible to lateral displacement under pressure. Practically all clays contain some sand, and, as the sand content increases, the plasticity decreases; likewise the supporting power is improved.

Hard-pan (a term sometimes loosely applied to any firm natural soil to distinguish it from filling, peat, or silt) is properly a cemented mixture of sand and gravel or of sand, gravel, and clay. Sometimes the cementing medium is iron oxid or a similar substance, but more often the clay supplies the binding material. In glacial formations, hard-pan is frequently encountered in the form of compacted boulder clay, which usually occurs rather close to the underlying ledge rock. This is an unsorted mixture of clay, sand, gravel, and boulders, which has been deposited sometimes in sheets, and more often as huge drumlins or hills, as a consequence of the grounding of the glacier upon peaks of rock projecting upward from the ledge. The subsequent melting of the ice permitted all of the accompanying detritus to spread itself over the ledge without the usual sorting action which took place when material was precipitated for a considerable depth through water. Every subsequent advance of the ice sheet over this material served greatly to compress and consolidate it, so that we now find it in a decidedly compact state. Whether hard-pan has been formed as a result of glacial action, or has resulted from the action of some flux such as iron oxid, the fact remains that it is a most excellent foundation medium and is capable of resisting high unit pressures. Loads of from 10 to 20 tons to the square foot are frequently allowed upon such a soil, depending upon its relative compactness. The lower figure is at least conservative in amount and any material properly entitled to the term hard-pan should be uniformly safe under such a loading.

There remains still to be considered the bearing power of ledge rock. In the opinion of the writer, practically any sound ledge rock will satisfactorily support such loads as ordinary masonry is capable of transmitting to it. That is to say, the stone, brick, or concrete masonry which distributes the load upon the surface of the ledge will itself be crushed by the pressure long before the supporting rock will fail under the same influence. This belief is based upon the fact that the masonry pier or footing is unsupported laterally, whereas the area of ledge upon which the load is applied is entirely surrounded by sim-

ilar material which would have to yield before any failure could result.

Information gained from the crushing of small cubes of rock is entirely misleading when applied to the action of ledge rock in its natural position. Recently the writer's firm made a test of the supporting power of some rather poor mica-schist ledge under the footings of the new building of the Insurance Company of North America, in Philadelphia. The material was too hard to pick, but was much softer than the rock encountered at somewhat lower depths. A steel plate, 12 inches square, was embedded in cement on top of this rock and a test load applied in the usual manner. A total load of 94 tons on this single square foot produced a net settlement of only ¼ inch, and this was evidently in the permanent shortening of the vertical timber. Nevertheless, limitations of from 15 to 25 tons upon hard ledge rock are not uncommon in many city ordinances, while at the same time allowances of from 30 to 40 tons are made in the compression stresses of concrete masonry.

A consideration sometimes overlooked by the foundation engineer is the possibility of utilizing a layer of strong material as a distributing medium for spreading the load over a greater area of some underlying softer substance. For example, strata of sand and gravel frequently overlie deposits of soft clay. A unit loading of six tons per square foot may be justified so far as the gravel is concerned, while a much smaller unit would be required in the case of the soft clay. However, in case the layer of gravel or sand is of substantial depth it will act as a distributing mat much as a mat of concrete is often used, with the result that when the load reaches the surface of the clay it is spread over a sufficient area to come well within the allowable pressure for the softer material. In problems of this character it is customary to assume that a load applied to a layer of hard material, such as sand or gravel, will be distributed downward at an expanding angle of 30 degrees with the vertical.

When the loading to be carried is of such magnitude that the lot is of insufficient area over which to distribute the load without stressing the available soil strata beyond their safe limits of resistance, there is nothing to do but to carry the supporting footings to ledge. This may be done by ordinary excavations and piers or by some form of caisson construction. In some instances, one or more of the several varieties of piling may be utilized for such a purpose. On the other

hand, if the load is not unusual in amount, and if satisfactory bearing material is available at or immediately below the ground surface, ordinary spread footings are the logical choice. Between these two sets of conditions a great multiplicity of variation may occur and the problem of the engineer is that of determining what, under all of the existing circumstances, is the most efficient and economical course of procedure to follow.

When the upper layers of soil consist of filling, peat, or silt, or in some instances of very soft clay, the problem resolves itself into that of devising a method by which the load will be carried down through these unsuitable strata and be distributed upon the clay, sand, gravel, or hard-pan, whichever first presents itself as an available medium for this purpose. While, in such cases, resort may always be had to open excavated pits in which may be constructed pier footings, the method is usually undesirable from the standpoint of both the cost and time involved, and this is especially true where large volumes of ground water are encountered. The common alternative is piling.

Occasionally the existing conditions permit of driving piling of reasonable length to some very hard stratum, such as hard-pan or very coarse gravel, in which case the piles derive their support from end bearing, as would any simple column, and therefore are known as bearing piles. In the more common instances, however, piles do not, for one reason or another, reach such a favorable supporting material, but are driven to a sufficient depth to develop a very considerable resistance from the frictional contact between the exterior surface of the pile and the soil into which it is driven and which it greatly compresses in the process of its displacement. These are referred to as friction piles.

The oldest and simplest type of piling is of wood, utilizing the tree trunk with all its branches cut off. Obviously, the greater the diameter and the greater the length of such piles, the more surface will be subjected to frictional contact with the soil and the greater will be its supporting power.

It is customary to specify a minimum diameter for both tops and butts of wood piles. There is, of course, good reason for desiring liberal sizes for butts, since this assures a sufficient perimeter and provides the required frictional surface area. In case of bearing piles, or those driven through relatively hard ground, there is probably some

advantage in providing blunt points, thus presenting a good bearing area and providing against the breaking of a slender tip during the process of driving through rough material. On the other hand, when the piles are to be driven through relatively soft material, there is some advantage derived from the additional length of tip, which supplies a certain amount of frictional surface, but which it is customary to waste in the endeavor to obtain the specified tip diameter. This may not be an important consideration in most cases, but the wasting of this extra length is hardly justifiable.

The principal objections to the use of wood piles are their comparatively low value individually; the consequent necessity of using a relatively large number of them to support a given load, thus increasing the size of the masonry capping which surmounts the pier cluster; the danger of undetected breakage during driving, thereby destroying the supporting value; and, finally, the fact that they are subject to subsequent decay unless assured of permanent saturation by ground water.

In determining their safe supporting value, bearing piles may be, and frequently are, figured as ordinary columns. Friction piles, on the other hand, are usually given values determined by some arbitrary formula, the most common one being the so-called "*Engineering News* formula", $P = \frac{2Wh}{s+1}$, in which P equals safe load, in pounds; W equals weight of hammer, in pounds; h equals drop of hammer, in feet; and s equals average penetration under last few blows of hammer, in inches.

In addition, it is customary to assign maximum allowable loads to be carried on an individual pile, a common allowance being 10 tons for piles of soft wood, and 15 to 20 tons for those of hard wood.

Wood piling is usually unsatisfactory for driving through rough material, such as coarse gravel fill, because the hard driving required is apt either to break the pile at some point below ground, or to crush or split the upper end of the stick which receives the impact of the blow. So far as is known, wood piles will last indefinitely if maintained continuously in a wet state. It is not always possible, however, to assume the permanence of any given ground-water level, and there have been innumerable instances in which an assumed permanent water-level has subsequently been lowered with disastrous effects

upon wooden piling in the particular vicinity. This is probably the most compelling objection that can be raised against this type of construction.

As an alternative for wood piles there are now available several varieties of concrete piles. Perhaps the most satisfactory among these from the standpoint of construction and design is the precast type which is made in a mold of desired size with a proper amount of steel reinforcing to permit of its being handled by a pile-driving apparatus which drives it into the ground as in the previous case.

While this general type has a wide usage and warrants the adoption of much heavier loadings than are assigned to wood piles (from 30 to 40 tons per pile), they have some important disadvantages. They are relatively quite expensive. They require a long period of initial set before they may be used. In addition, their use involves the utilizing of a large area of ground as a casting yard, and this is frequently unavailable. To cast them elsewhere and transport them to the site involves a prohibitive expense in the present state of the art. To overcome these disadvantages there have been developed many ingenious methods for constructing concrete piles in place, thus eliminating the principal disadvantages of the precast method.

In practically every such case, a metal form of some sort is driven into the ground just as any pile might be driven. When the proper resistance has been secured the form is filled with concrete. In some cases, as with the Simplex and MacArthur systems, the form consists of a plain cylindrical tube 16 inches in diameter, which is withdrawn when the concrete is in place, thus leaving an unprotected cylindrical column of plain concrete of uniform diameter in direct contact with the soil. In other cases steel pipes are used as forms and left permanently in place, forming an integral part of the completed pile. In at least one type, steel tubes are first driven, after which very light sheet metal forms are dropped inside of these tubes and filled with concerete, the main tube being subsequently withdrawn, allowing the surrounding soil to squeeze in and grip the interior pile and its form which remains in place.

The object of leaving some kind of outer form in place is to protect the fresh concrete from distortion or displacement during the process of driving subsequent piles in the immediate vicinity. There have been many instances recorded in which serious distortion of un-

protected built-in-place concrete piles has occurred. It should be said, however, in fairness to these types of piles that these results have usually occurred under somewhat unusual combinations of circumstances. Nevertheless, the presence of these conditions cannot always be detected in advance, nor is the objectionable behavior apparent to the observer during the process of driving. In such cases the defect is often undiscovered until after the permanent load has been applied and settlement has manifested itself.

The objection to leaving the protecting form in place is that of expense. To meet this situation, the Raymond pile was devised some twenty to twenty-five years ago. In the installation of this type of pile, a very light, tapered, sheet-iron form—composed of short sections telescoped together stove-pipe fashion so as to give a continuous form 8 inches in diameter at the tip and 20 inches at the butt—is fitted over a heavy steel mandrel or core of similar shape, the whole being driven into the ground as a unit by the use of a heavy steam-hammer. When final resistance to further penetration has been secured, the mandrel is collapsed and withdrawn, leaving the light shell form in the ground. The sections of shell are grooved in a spiral direction, and in the groove there is inserted a ¼-inch diameter steel spiral rod, thus reinforcing the shell against collapse from exterior pressure. The interior of the shell is then filled with concrete, giving a pile of pronounced taper, reinforced against subsequent distortion by the surrounding shell and its spiral stiffening rod. By this means, protection is afforded to the fresh concrete at a minimum of expense.

There is one general consideration that should control every design for pile foundations. There is no magic result to be expected merely as a consequence of driving a pile into the ground. Its function must be clearly understood and provision made for the proper exercise of this function. The main purpose of its use is to transfer a definite load down through layers of unsuitable soil, either to impose that load upon a lower stratum of good material, or to compact a uniform material so that it is capable of sustaining the pile by friction. Unless, then, the pile does this, it serves no useful purpose.

The fundamental theory involved in the use of piling is a simple one. By means of the intimate contact developed between the outer surface of the pile and the surrounding soil, the vertical load acting downward in the pile is transmitted to the soil around it. Every suc-

cessive foot in depth of pile transfers some of its load to the adjacent ground with which it is in contact. If a friction pile is properly designed and driven, before the load reaches the pile tip it has been entirely absorbed by the soil. The zone of soil which is thus stressed resembles in form an elongated vertical cone, with its apex at the upper end of the pile, while its base is coincident with the horizontal plane at the level of the pile point. It is this cone of soil, and not the pile itself, which distributes the load over the supporting stratum, and it will be readily seen that when the pile point fails to reach good soil the load which it carries will be applied to the stratum of poor soil in which the top rests, and the pile support afforded in such a case will be no better than that of the inferior stratum in question. The lateral dimensions of this cone of pressure vary according to several factors in the problem. Some soils, such as peat and silt, are easily compressible and the contact with the pile surface is apt to be somewhat negligible as a friction-producing factor. Materials such as stiff clay or layers of fine dead sand, on the other hand, are displaced only with the greatest difficulty, and consequently there is developed an enormous pressure reaction between the pile surface and these soils. The spread of the pressure cone in the latter instance will consequently be much greater than in the case of the former.

Having in mind the fact that the load is finally carried by the soil in which the pile point is embedded, it is possible to determine the proper spacing of the several piles in a cluster. By assigning a proper unit bearing value to the supporting stratum, the precise area required to carry the total pile load is found and a spacing should be adopted which will permit the individual pile to spread its load over such an area without interference from the overlapping pressure cones of adjacent piles.

While the various available types of piling are capable of supplying the needs of the great majority of foundation problems involving the transfer of loads to considerable depths, there are many limitations and difficulties frequently involved in their use. Some soils, especially those containing coarse and rough materials, such as gravel and boulders, render the use of any form of piling difficult and often prohibitive. The absence of a satisfactory supporting stratum within the practical limits of depth may involve the use of such great length of piling as to eliminate its consideration. Extremely heavy concen-

trated pier loads may require so large a total number of piles in the individual cluster as to call for very expensive masonry footings by which to spread the load equally over the several piles.

To meet these conditions when they arise, resort is sometimes had to the caisson method, by means of which a column or shaft of concrete is carried down to rock or other hard medium either by the undermining or sinking process or by excavating for the exact displacement of such a shaft and subsequently filling the space with concrete.

In the first instance, a shallow excavation is first made, concentric in position with the proposed pier location and slightly larger in area than that of the footing. In this space, forms are erected and the masonry of the permanent footing is begun therein, leaving at the base, however, an interior hollow chamber with a communicating shaft opening extending upward to the surface. Workmen then enter the working chamber through the shaft and excavate beneath the surrounding edges of the footing, thus permitting it to settle, the operation being repeated continuously until the desired depth has been reached. Meanwhile, as the sinking process proceeds, more concrete is added to the upper portion, thus maintaining its level at or above that of the surface. When ledge or other selected hard bottom has been reached, the working chamber and communicating shaft are filled with concrete and thus a solid monolith of concrete is procured, extending from the hard bottom to the surface of the ground. When excessive amounts of ground water are encountered, or material which gives trouble by running into the opening during the process of sinking, compressed air may be resorted to for the purpose of counteracting these influences. In such cases, air-locks are attached to the top of the shaft opening and the customary pneumatic procedure is followed. This method is in common use for installing the foundations of many high buildings constructed in the down-town section of New York City. It is also frequently employed in bridge-pier construction and has various adaptations.

Some thirty years ago a method of open-well construction was adopted in the city of Chicago for carrying building columns down through the thick underlying bed of soft clay to hard bottom at from 60 to 100 feet below the ground level. This is generally referred to as the "Chicago caisson method." Circular excavations of the exact cross-sections of the column shafts required are made at the location

of each building column. As the excavation proceeds, the walls are lined with wood staves, two by six inches, and four to five feet in length. The lining is maintained in position by interior steel rings made in two pieces and bolted together by means of flanges. Additional sets are inserted as the work progresses. When the desired depth is reached, the opening is concreted and the lining may be removed as the filling proceeds or it may be abandoned and left in place. In case these shafts rest upon some material other than ledge rock, it is customary to chamber out the lower portion in the form of a truncated conical frustum which, when filled with concrete, serves as a spread footing to distribute the load on the underlying soil within the safe limits of its capacity.

A modification of this method was devised by the writer several years ago and has had wide usage, particularly in the eastern portion of the country. This system is illustrated in Fig. 2. Instead of lining the excavation with wooden staves, light steel cylinders are employed in sets, the individual cylinder being from five to eight feet in length. The successive cylinders in a set vary in diameter by two-inch increments. The largest cylinder is first sunk by excavating below its cutting edge and driving it down. This is followed, in turn, by a second cylinder two inches less in diameter which is dropped inside the first one, and similarly sunk for another five to seven feet below the first. In this manner the opening is lined down to the desired depth. If required, a bell-chamber is then excavated as in the Chicago method and the opening filled with concrete. As the concrete filling progresses, the cylinders are withdrawn in reverse order of their original placement. The cylinders are more easily and quickly placed than is the wood lining, although, for great depths, the increased diameter of the upper sections over that theoretically required to carry the load necessitates some undesirable waste both of excavation and of concrete. When this variation between theoretical and actual diameter is considerable, the waste of concrete can be avoided by using a small-sized cylinder inside of which to deposit the concrete, filling with sand the annular space between this form cylinder and the outer lining cylinder as the filling process proceeds.

While the wood-stave method may be successfully applied to the impervious clay generally encountered in Chicago and some other locations, it would be unsuited for water-bearing soils such as loose fills

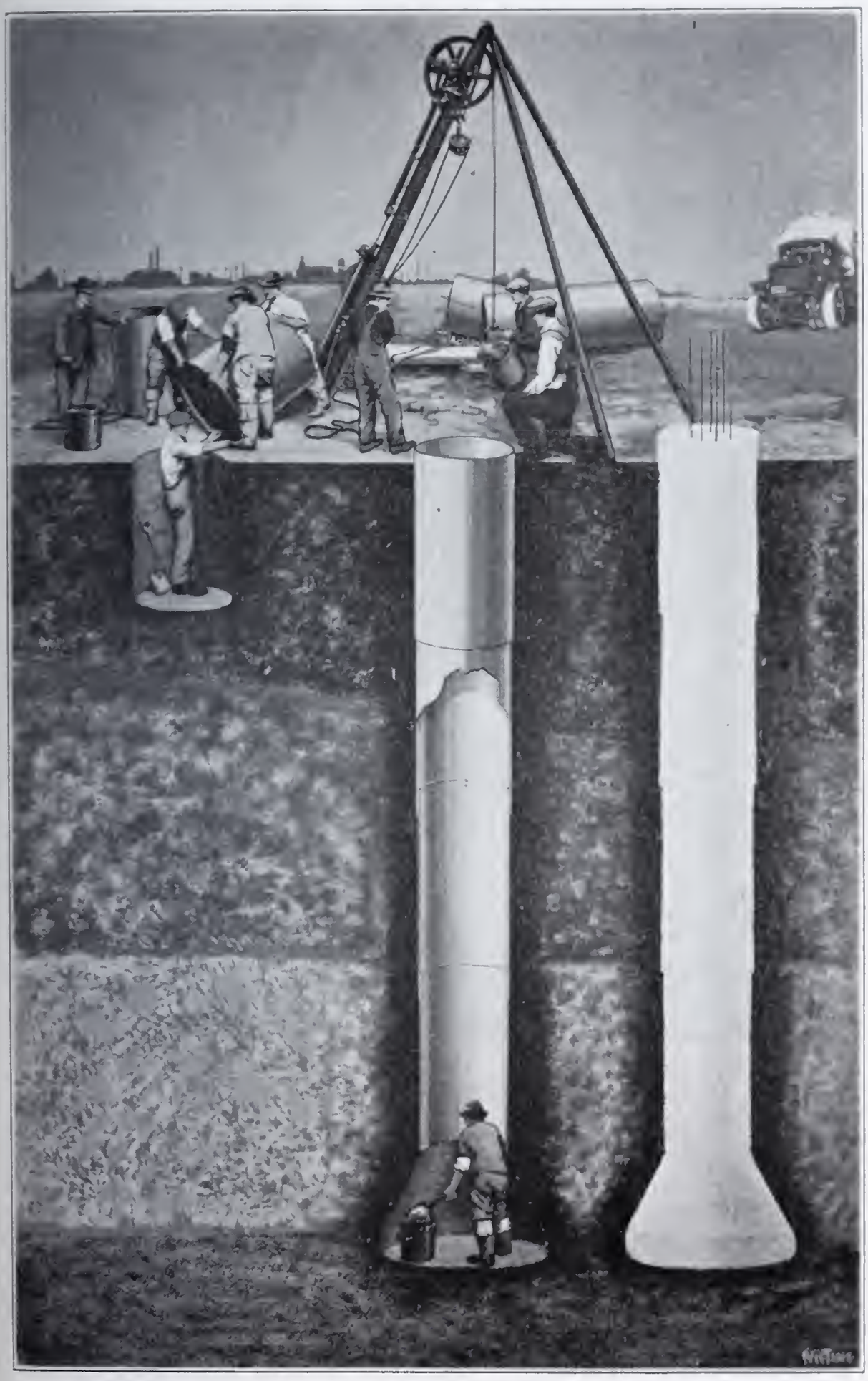

Fig. 2. Standard Method of Constructing Gow Caisson Footings.

and the like frequently encountered elsewhere. Steel cylinders, on the other hand, act as coffer-dams to exclude the ground water, and also as vertical shields which may be driven somewhat in advance of the excavation, thus preventing any tendency for the surrounding soil to

Fig. 3. View Looking Down Cylinder-Lined Open Well.

flow into the opening. A view looking down into one of these cylinder-lined wells is shown in Fig. 3. This was taken from a photograph made during the installation of some of these foundations in Pittsburgh, for the Philadelphia Company's new building.

Not every soil will permit of excavating a footing chamber at the base of these open wells. When such a situation is encountered, resort may be had to another method devised by the writer and his associates and frequently used by our construction department. This is illus-

trated by Fig. 4, which shows the sequence of operations. A working chamber of concrete is built in a shallow excavation, having the necessary dimensions for the final footing. This is undermined and sunk in the usual fashion except that no further concreting is done during the process of sinking. Instead, sets of steel cylinders are pulled down by the concrete chamber as it settles, and the space between these cyl-

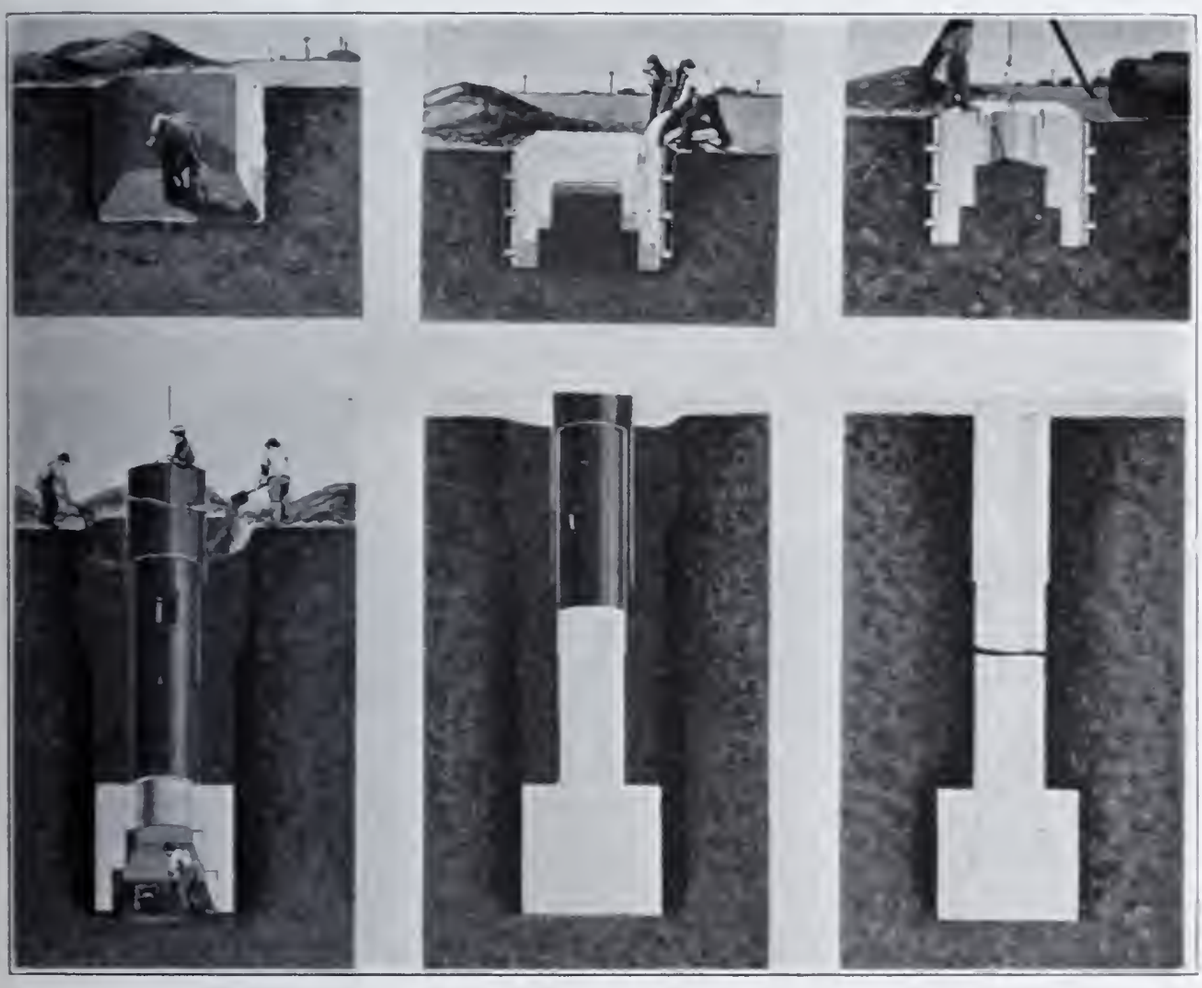

Fig. 4. Sequence of Operations in Sinking Gow Caisson Precast Footings.

inders and the walls of the excavation left by the larger cross-section of the concrete footing is backfilled with a portion of the excavated soil removed from the interior. This backfill serves a double purpose; it refills the space between this shaft and the sides of the larger excavation, and, at the same time, adds weight on the roof of the concrete footing chamber, thus aiding in forcing it down. Whereas the ordinary straight-sided caisson encounters increasing difficulty in sinking at the greater depths, by this method the surface exposed to frictional resistance is always constant, while the weight of backfill increases with the depth and so facilitates the desired movement. When the

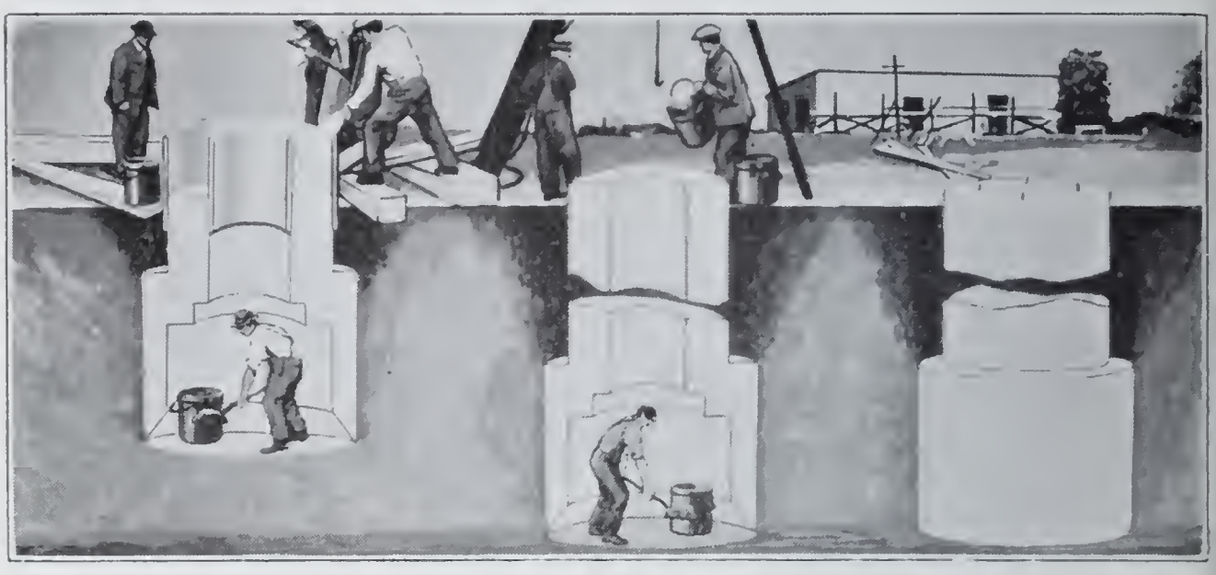

Fig. 5. Special Method Adopted for Precast Bell-Type Gow Caisson Footings.

Fig. 6. Interior View of Working Chamber. Pneumatic Caisson for Double-Cantilever Column Footing.

footing has reached good bottom, the working chamber is filled with concrete, which is also carried up through the shaft by the method previously described. This method was recently successfully applied in the installation of several footings inside one of the buildings of the Westinghouse Air Brake Company, at Wilmerding, Pa.

In case the depth of these caisson footings is considerable, or if it is necessary to use the pneumatic process, a hollow concrete shaft of uniform cross-section is used instead of the steel cylinders. This system is illustrated in Fig. 5. In this construction, an air-lock can be formed by inserting in the shaft opening two lock-head diaphragms, which may subsequently be removed. Fig. 6 illustrates the interior of such a footing sunk by the pneumatic process in connection with the foundation installation of the new First National Bank Building, in Boston. Fig. 7 shows the method of installing caisson for Gow footing, using precast shafts.

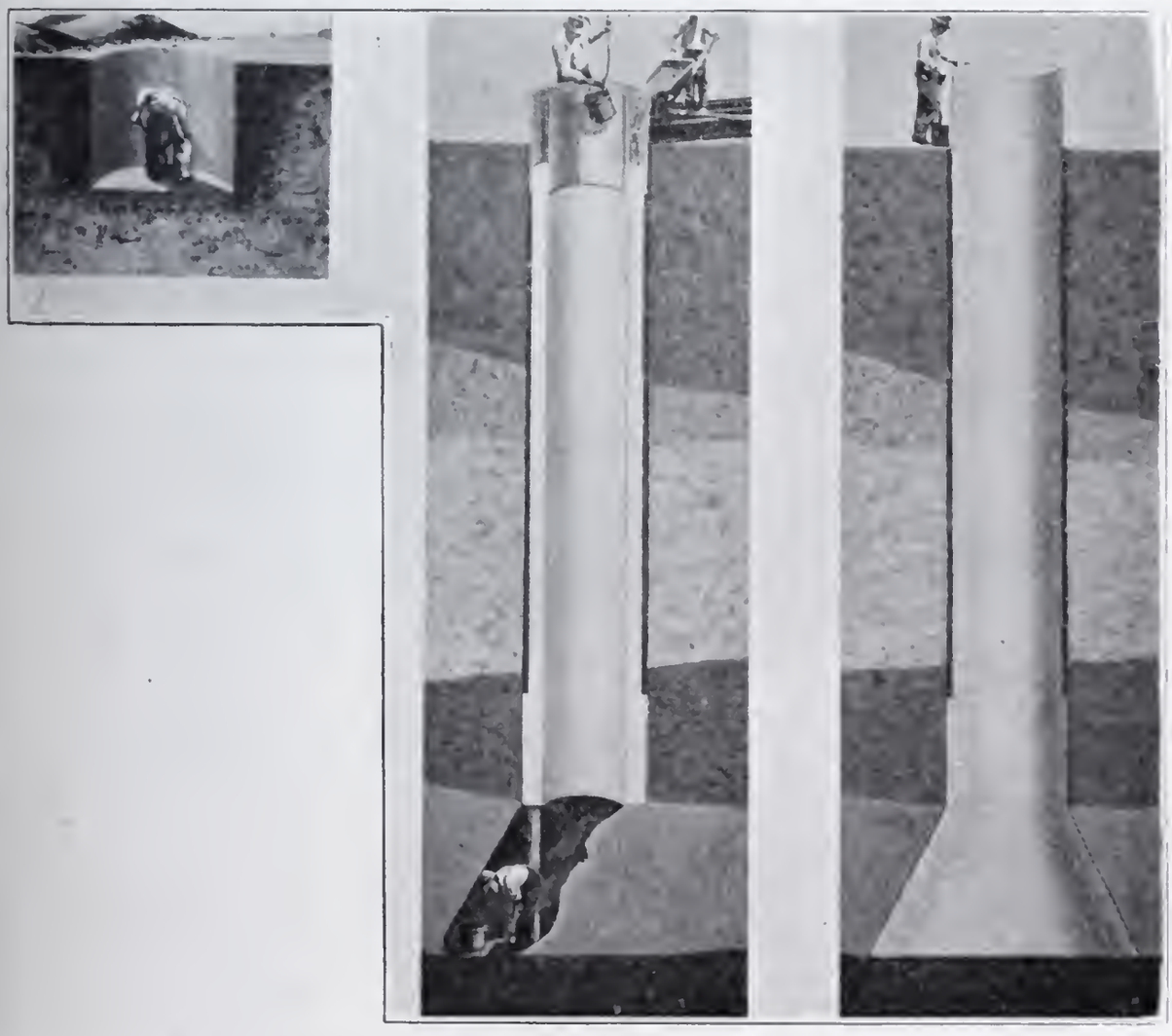

Fig. 7. Method of Installing Caisson for Gow Footings, Using Precast Shafts.

The writer realizes the fact that much that he has herein recorded is elemental in character. Some of the matters treated are found in current text-books on the subject. Other statements express facts of common knowledge. Nevertheless, constant reiteration of these principles and theories can do no harm, and may be found useful, especially to the beginner and those who have but slight experience in foundation construction. If the statements and opinions expressed herein result in stimulating some discussion from those whose experience and knowledge qualify them to speak with authority on this important subject, the time and labor expended in the preparation of this paper will not have been in vain.

DISCUSSION

Mr. E. L. Daley:* I want to thank the Secretary, Mr. Treschow, for the opportunity of reading Col. Gow's carefully prepared, exhaustive study of foundations. I agree with Col. Gow that the reiteration of the elementary principles governing all practice in foundations is always most important. This paper is so readable that it gives a pleasing turn to well-known principles. I note that the discussion does not enter the field which is of great interest to many of us—namely, foundations for river structures such as dams, locks, retaining walls, water intakes, etc. The problems in this field introduce forces which complicate the study; yet the same elementary fundamental principles govern. The importance of the fullest knowledge of the underground conditions are, if anything, more important in foundations in water than those on land.

The difficulties of interpretation of subsurface conditions from a large number of wash borings and cores warrant Col. Gow's statement that enormous sums of money are wasted yearly as a consequence of inadequate or misleading information. The judgment of no single engineer can be held infallible, in the present state of knowledge along these lines, in making what is at best only a diagnosis of the particular case under study. Depending on the importance of the structure to be supported, multiple independent interpretations should be sought. The old adage cannot be stressed too strongly—"An ounce of prevention is worth a pound of cure." A few additional, wisely placed borings may save thousands of dollars in foundation costs later. In this paper the complete discussion of soils, and of the combinations and conditions under which they may be found, is so detailed as to be authoritative.

Mr. Morris Knowles:† The Engineers' Society of Western Pennsylvania is fortunate indeed in having such an authority as my good friend, Col. C. R. Gow, Consulting Engineer, of Boston, present this paper on foundation problems. I am sure we can all read and study this paper with much interest and profit.

It is to be noted that the article deals with that which is strictly and correctly called "foundation"—the soil, rock, or under strata upon

*Major, Corps of Engineers, United States Engineer Office, Pittsburgh.
†President and Chief Engineer, Morris Knowles, Inc., Pittsburgh.

which the structure rests and bears—and not, as is sometimes commonly used, and called the foundation, the concrete or other footings. The elementary treatment of the subject is serviceable and needs no apology, for many of us need to be reminded of several of the facts which should be within our common knowledge. We are sometimes apt, in our eagerness to obtain the answer in a certain design, to forget and neglect some of these elementary principles, and it is therefore wise for us occasionally to take account of stock.

The author states that, as there are comparatively few foundation failures involving serious consequences, one is led to believe that there is an unjustifiable and enormous economic waste in current foundation practice. There may be much truth in this remark, but may it not also be true that some types of foundation failures are not always detected because of the very fact that they are underground and out of sight? Some cases of failures of members in superstructure, even though apparently laid at the door of some faulty design, may have had their origin, if all of the facts could be made known, in some unequal settlement or slight foundation failure. Then, again, methods of correcting foundation failure are so expensive that one may be warranted some slight extravagance in design to endeavor to avoid such.

It is stated that foundation settlements, even as much as several inches, have occurred without detrimental effect upon certain structures, where the foundation is compressible and the settlement equal. This brings to mind the importance of equal distribution of loading and, in the design, more attention may well be given to such an equal distribution of pressure that equal settlement may occur. Even though no part of the foundation have a bearing load in excess of the safe value of the material, if there be portions which have a materially less load, unequal settlement may occur with compressible material, such as to produce unsightly or dangerous cracks or strains in the superstructure.

The writer remembers a recent problem in which it was proposed to design a reservoir foundation so that the floor would rest upon rock. While the excavation was in progress, it was found that the rock was so much lower on one side than on the other that it would mean considerable and expensive excavation to place the whole load upon rock as was originally intended. It was also originally provided

that by a slight change in location and elevation the entire floor of the reservoir could be placed upon compressible soil. It was, therefore, decided to change the design and call for less excavation, so that the reservoir could rest entirely upon one character of material instead of partly upon rock and partly upon clay.

In closing, permit me to say that the Society is to be congratulated, and the author should receive our thanks, busy man as he is, for his willingness to come and give us such a thorough paper upon so important a subject.

Mr. C. McDonough:* I have enjoyed Col. Gow's paper very much. I think he has covered his subject in a very thorough way, but more along a theoretical line than I had expected. I do not think he has overemphasized the necessity of good, reliable boring records in all cases. The cost of these investigations is saved many times over where good records are made. It is seldom that an accurate reading of the ground-water level is made. This is extremely important from a constructive standpoint and also of importance in determining the safe loading on several materials.

I do not believe that the applying of a test load by artificially weighting a small area of one or up to four square feet of ground will give a correct measure of its bearing value. This method in no way approximates the conditions of loading from a foundation.

We might apply a load of four tons to the square foot in a test with slight settlement and appear safe where the load is spread to the underlying strata in a cone of pressure. Some underlying strata may be less suitable, but would not show in this test. At a depth of 30 feet the test load per square foot may be spread so that only a small part, perhaps one four-hundredth, of this load is placed on a square foot of the underlying strata. If, however, the actual loading happens to be an ore pile, or a building with a heavy floating foundation carrying four tons over a large area, the ratio of spread on the underlying or critical strata will be decidedly different, perhaps one half of the loading per square foot will be transmitted, together with the weight of the intervening strata on these critical strata below, resulting in an actual load many times greater than the test would indicate. For loadings of an extensive character the test loading results would be

*Assistant District Manager, Foundation Co., Pittsburgh.

erroneous. Test loading may also give a wrong impression as to safe loadings when water is present in the excavation. The percentage of water is very important, as it changes the angle of repose of materials and the volume of clay. When water is allowed to accumulate on the exposed surface of the soil to be tested, and the surcharge removed as in a pit, the exposed material will increase its percentage of moisture.

I believe this to be the reason for the queer behavior of the clay hard-pan Col. Gow describes in the pneumatic caisson in Boston. When the caisson was allowed to fill with water and soften the bottom, the clay changing its moisture content, a safe load of only 1.5 tons per square foot was recorded; but, when the bottom was protected with a concrete seal and the water allowed to fill the caisson from the ground above, the bottom being protected from the water, a load of six tons per square foot was obtained. In the latter case, the clay did not change its moisture content from what it originally had. It was, therefore, found safe and carried the load that actually came upon it when tested in its natural state.

It is my opinion that a fixed rule can not be set for bearing value of sand or gravel. I have known cases where six tons per square foot was too high for sand. For example, with a very coarse grade of sand considerable settlement occurred with six tons, and when this foundation was underpinned and the load spread to give only four tons per square foot no further settlement was recorded. We have used loads as high as eight tons per square foot on gravel and have not as yet seen any settlement unless the foundation was undermined by outside forces.

I do not agree with Col. Gow that sand and gravel can take the same loading. Gravel, as we find it in nature, is both small stone and graduated sand, will weigh more per cubic foot than plain sand, and has a steeper angle of repose, especially under water. Both of these conditions affect its bearing power.

Quicksand as a foundation material can hardly be considered. No matter what method is used, quicksand will be shifted and made unfit to carry foundations. Even with the pneumatic method, going through this material causes some shifting and any kind of pumping would cause a movement. After this material has been disturbed it will not regain its original compactness and is no better than a back-

fill which has not been compacted. The mere raising of the ground water in the excavated pit to the same level as that of the surrounding ground will not put this material in equilibrium, as the balancing pressure due to the overlying ground has been removed. Quicksand often contains more clay than coarse materials and this has a greater lubricating effect on fine sand.

Clay is always safe to load to the same amount per square foot as that to which nature has compressed it by the overlying materials, providing the overlying materials are removed and it is still confined and the moisture content not changed. When you consider that a 25-story building would weigh only about two tons per square foot of basement floor, it is simple to make a floating foundation to cover the whole area after the basement has been excavated, without changing the equilibrium of the clay. It is also possible to exceed this amount, but the percentage of moisture in the clay should be closely measured. By using what is known as the Chicago well method and belling out in the clay at a greater depth this same principle is applied. The moisture in clay will run from 10 to 32 per cent. by weight and at the latter figure the clay will flow like cream. It is often found that the higher percentage of moisture will be at a greater depth or different strata found in the same clay bed. A sand or clay foundation is generally a problem in itself. It requires careful study and, therefore, is not subject to any fixed rule.

Mr. T. B. Sturges:* Mr. Gow has certainly given us a very fine paper. I have been in the test boring business for 20 years trying to find the best method to be used to support structures and I find a wide variation of opinion. Engineers have differed with me as much as 1000 per cent. in the load they would permit on the same stratum. Most engineers are too conservative, I believe. After they find the exact conditions, they have to use their own judgment and they desire to play safe. We do not have statistics of tests, and the actual figures of loads that have been carried on different materials in various localities. That is something we ought to have published, if we could get from such members as we have here their experience along this line. If we could get a compilation relating to buildings and loads that have been successfully carried in different parts of the country it

*President, Pennsylvania Drilling Co., Pittsburgh.

would mean a great deal to the people who are always meeting these problems. I have drilled in a great many states, testing for foundations for bridges, dams, and buildings, but I do not believe there is any place in the country where we have more variations than right here in Pittsburgh. You do not have to go very far to find entirely different conditions. At one time all Pittsburgh was at the same level as the top of Mt. Washington. The rivers have cut down and made the channel through here and, in doing that, have made a tremendous difference in their gouging and refilling with different materials.

In building this hotel where we now are, along William Penn Way, the caissons had to go down to a considerable depth to find any bearing value. At the east side of the building it was only a few feet to bed-rock. At the Frick Building it was necessary to excavate a large quantity of rock, and at the City-County Building they had to excavate solid rock for the basement. At the Philadelphia Building, across the street from here, they had to go down to rock and they found it within a reasonable distance. The Telephone Building foundations were 60 or 70 feet to rock. At the Kaufmann & Baer Building they have gravel. Go the other way to the corner of Diamond Street and William Penn Way; there they have a vacant lot where they park automobiles, and you can see the rock projecting three or four feet above sidewalk level. At the Salvation Army Building on Second Avenue, another block away, there is no rock 65 or 70 feet down and no gravel. You have such varying conditions all over town. When we undertake to plan anything, the plans are always liable to be upset, as conditions often differ so much from the expected.

There can be no question that Col. Gow is right in saying that borings ought to be made, and engineers ought to select sites first. If we only had these figures of loads that have been used, we would have something better to work with than anything we have now, as at the present it is a matter of opinion and a great deal of guesswork. There are one or two other things that might be added, such as the changes in water-level. In some places the water-level has subsided during the years and has changed conditions. There has been as much as 100, and in some instances, 200 feet of drop in 20 years. Then there are the clay beds which once were saturated and have since dried out. Some of these clays do not contract in drying, but rather become a porous clay which will compress greatly with a load. Clays of this

kind may readily absorb water during the wet season, and dry out later.

I do not know whether it would be in order, but, just to see what the idea might be, I would make a motion that the architects and engineers here send in to the Secretary such data as they have as to tests and loadings and have them published with Col. Gow's paper. The information needed would be the name and location of the building; the load per square foot; description of subsurface strata used to carry load; and the method used.

We have often bored through concrete piers, taking out a core of the pier or whatever the structure might be, and we find places where there is a much larger percentage of gravel than sand, and places where the sand has accumulated in layers and sections. I rather think this may be due to cases such as where the mixture is carried on a long slide for dumping into a pier, and naturally the larger stones roll and the fine material will not. That condition has been found many times and there is more or less of a segregation of the different sizes.

I do not entirely agree with Col. Gow when he figures that sand will carry the same load as gravel and sand mixture. I like the gravel best for carrying loads. Take our gravels and fill in between with sand and you have a load that is going to spread. With sand, you do not get the spread to carry the equal load because the grains do not support themselves. The gravel has that tendency. It is a more compact mass. There is not the same chance for the grains to work together. If you look at sand through the microscope you will find that the grains are uneven and of different shapes, and if you put pressure on these grains there is more or less chance to squeeze them together, which you do not have with a pile of cobblestones held in place by the sand. I would rather carry a large load on good gravel than on sand. I may be wrong, but that is my idea.

Mr. C. N. Haggart:* I remember that some years ago a very excellent paper regarding sand was read here by Mr. F. M. McCullough, and he showed some tests made on dry sand and damp sand. The dry sand was much heavier per cubic foot than the damp sand, which would seem to show that the sand had a larger volume when it

*Structural Engineer, Pittsburgh.

was damp than when it was dry. It seems to me there might be some slight compressibility in sand that there would not be in gravel.

MR. F. M. MCCULLOUGH:* Those tests, which were reported in the May, 1915, PROCEEDINGS of this Society, were made on damp sand, as delivered; and on the same sand, thoroughly dried. We found that the bulking factor action averaged about 20 per cent. for sand containing five to six per cent. of moisture; that is, 1.215 cubic feet of damp sand will have a volume of one cubic foot when thoroughly dried. If the moisture content is increased until the sand is flooded, the percentage will rapidly decrease.

MR. C. N. HAGGART: At the same time, there must be some pressure on the sand and the grains must come into closer contact when it is under pressure than when it is not.

MR. WINTERS HAYDOCK:† The remarks of Col. Gow with regard to the bearing capacity of sand under pressure remind me of an incident in my own experience where I suppose the grace of God had more to do with keeping a structure standing than the skill of the engineer who originally built it. I had charge of the rebuilding of an old railroad bridge over the Arkansas River. It was built some 35 years before and was supported by iron cylinders about seven inches in diameter filled presumably with concrete. The original spans were 200 feet and the new spans we were building were 250 feet, so that in two instances the new spans coincided with the old spans in location. In those two cases we cut down the old cylinders inside of the caissons of the new piers as these were sunk in the bed of the river. The new piers went down to 70 feet below water-level. In cutting off those old cylinders we found that instead of being filled with solid concrete they had alternate layers of concrete and pure sand, six to ten inches thick. This was evidently due to the fact that the concrete was deposited in water and allowed to settle through the water so that the cement was washed out. The cement and finer particles of sand settled later and formed a layer of very dense concrete. The grace of God entered into the question through the fact that the piers stood up and carried their load for some 35 years. If those iron cylinders had

*Professor of Civil Engineering, Carnegie Institute of Technology, Pittsburgh.
†Chief Engineer, Citizens Committee on City Plan of Pittsburgh, Pittsburgh.

rusted off and thereby subjected the sand to the scouring action of the water, I do not know what would have happened.

Mr. F. M. McCullough: In one of those slides, I think, I saw a buggy dumping into one of the caissons. Have you made any investigation to determine whether there was any segregation of the coarse aggregates and, if there was segregation, have you used any remedy for it?

Mr. Charles R. Gow: My feeling with regard to that is that when concrete is dumped into an open hole there is no separation due to the dropping of the material, because it falls as a mass. At least, there is no observable separation. When the concrete is in a plastic state, as it usually is in such cases, it falls on the preceding concrete and the mass levels out. In the case of deep holes, we usually dump through chutes, thus preventing the material from scattering on the way down, and if the mixture is sufficiently fluid it will flatten itself out when the buggy load of concrete drops on the peak of the pile of concrete already deposited, and will automatically level itself. I do not believe there is any material separation caused by dropping concrete through air. We all know that there is if it falls through water. As far as I have been able to observe, the entire load arrives at the bottom at the same instant.

Mr. P. J. Freeman:* I want to emphasize this one point which Mr. Gow brought out about the testing of various rocks, shale, coal, or whatever it may be, by taking a small piece to the laboratory. There is a tendency to place too much confidence on the results you get, just as the speaker stated. It is probable that most of the data you have in your books are aboslutely worthless as far as actual value of the bearing power of rocks is concerned. It has been found by the United States Bureau of Standards that many materials which handbooks show to have a bearing power of about 10,000 pounds per square inch as usually prepared, with polished surfaces, will stand over 40,000 pounds per square inch. This is true for almost any material except concrete, where we can smooth it up with plaster of Paris. A material running up to 8000 or 10,000 pounds must be polished on

*Chief Engineer of Tests and Specifications, Allegheny County, Pittsburgh.

the ends like plate-glass to get the highest results. All ordinary tests will be ultraconservative.

In connection with the clay, I am particularly interested right now in foundations for roads. The United States Bureau of Public Roads is conducting very elaborate tests on the holding power of clay for moisture. You can tell by tests whether or not any particular clay will hold lots of moisture. If it does, we do not want it for the foundation of a road. Undoubtedly, the same would hold good with foundations for buildings.

Also, I should like to emphasize what Mr. Gow told us about drilling. I had something to do with a bridge several years ago and, fortunately, after the work had started, we took some drillings and found that underneath the top layer of what was supposed to be solid rock there was soft clay for about two feet. If we had built the bridge on that, we would have had a large settlement at one end. Drillings taken at the other end of the bridge showed solid rock. We should not put up even an inexpensive structure without knowing by actual drilling what is underneath.

Mr. James S. Martin:* The author spoke of the fact that other branches of the engineering profession have reduced their operations to a scientific basis, while the designers of foundations have not been able to do so. I do not know whether the design of foundations will ever be reduced to the same scientific basis that the design of steel and other structures has been. In cases where we can control the composition and manufacture of the materials to be placed under stress we can arrive at fairly definite conclusions as to their physical properties. The composition of material on which foundations for buildings and other structures must be placed is beyond human control. The tests which might be made in one locality may show the earth to be capable of sustaining certain weights, but that furnishes no criterion on which to base absolute assumptions as to the bearing power of soil in other localities. As the author has said, we cannot trust to appearances, and it is sometimes hard to tell whether you are working with a fill or in natural soil. I have two cases in mind illustrating this point. The first case is that of a building near Pittsburgh. The contractors thought they had a solid clay footing. The inspector was satisfied

*Structural Engineer, Philadelphia Co., Pittsburgh.

that he was in a natural bed of clay, but he said, "Dig down about six inches more and I think we will be all right." They went down the six inches and found a lot of old cans and rubbish that had been deposited there some time previously, showing that they were digging in a fill which had all the appearance of solid clay. In another case which I was able to observe, some digging was being done through what appeared to be very solid earth. They even came to a stratum of what seemed to be soft sandstone about two or three inches thick. About one foot farther down they came to a layer of leaves which looked almost as fresh as if they had blown from the trees the fall before. There was nothing in the appearance of the ground to indicate that it was a fill. On investigation we found that this ground had been filled about forty years before. We were not able to account for the stratum of stone except on the assumption that some sand and lime had been deposited there and had hardened, giving it the appearance of stone.

For the above reasons I do not believe that the calculations on safety of foundations can be carried out as accurately as can be done when dealing with other materials of known properties.

The question of the separation of sand and gravel in depositing concrete has been brought up. A notable case of this will be found in the dike on the main-channel side of Brunot Island in the Ohio River. The concrete for this dike was deposited at the top and allowed to roll down the slope to the bottom as the construction advanced. The facing boards have now fallen off and the composition of the concrete is exposed to view. This shows very distinctly layer after layer of cement mortar alternating with layers of coarse gravel, showing that wherever concrete is allowed to roll down a slope the particles of different sizes will separate. Where the material is carefully leveled up after each deposit, I do not believe there will be any separation.

As to the difference between the bearing value of sand and gravel, I believe that the gravel as ordinarily found in banks is better bearing material than sand alone. If the gravel is of uniform size and unmixed with sand, the percentage of the space occupied by solid material will be about the same as it would be in a sand bed where the particles of sand are approximately of the same size. Gravel, as it is ordinarily found in gravel beds, however, is mixed with sand and the particles are of various sizes. It is a well-known fact that the

densest mixture that can be placed in any certain space would consist of very large pieces placed first, with other pieces large enough to fill in the voids, and so on down until a very fine mixture is added to fill in the final spaces. The larger the pieces with which you start, the denser your final aggregate will become. Besides this, the heavier pieces of gravel are not so much affected by the hydraulic pressure of which the author speaks.

For these reasons I believe that a gravel bed, as it ordinarily occurs in nature, is a better support for foundations than a sand bed.

Mr. E. V. Braden, *Chairman*:* As the speaker of the evening must leave, I will ask him to reply to the discussion as far as he may desire.

Mr. Charles R. Gow: I am very glad that this discussion has been provoked, especially as to the theory of the uniform capacity of sand and gravel. I am not at all surprised at the difference of opinion which has developed, because in my own locality I am considered somewhat radical on that particular theory. I still feel convinced, however, from my own observation and experience, that there is ample justification for my theory. At the same time, it should be considered as only one man's opinion.

It would be interesting if some of our technical colleges could be induced to undertake some laboratory experiments along this line. The principle could easily be tested by confining sands of different textures, together with gravels and sands mixed, in a cylinder and compressing them. It is my opinion that there is no essential difference in character, whether the interstices of gravel are filled with sand grains, or whether similar interstices among minute sand grains are filled with smaller grains of the same material. The only difference is one of relative size of particles, and I can not believe that this difference alone can be expected to produce different results under loading. I hope that this discussion will provoke the thought in the mind of some one in position to do so, to carry on some scientific experiments in an attempt to obtain reliable data. My own opinion is based entirely upon observation, experience, and practice, and not upon definite experiments by which to compare the two cases.

*Engineer, Pittsburgh, Chartiers & Youghiogheny Railway Co., Pittsburgh.

As I have previously stated, my purpose in preparing this paper has been to provoke discussion, and unless it accomplishes that it will not be particularly helpful to you. I trust this little thought left with you may result in such discussion, and if it brings about any results in the way of positive information it will be very helpful to the profession as a whole.

Mr. E. V. Braden, *Chairman*: On behalf of the members of the Society I wish to extend to you a very cordial expression of our appreciation for your trouble in coming here and starting something that I believe will be of value to the profession. There is a lot of talent that could add to the matter and, as this Section has undertaken constructive work before, this is another opportunity to do the same thing. We have a resolution which asks for this information, so that can be combined and put in shape where we can get at it. It will give to the profession at large such information as you know is reliable and it may be useful to the craft.

BOARD OF DIRECTION

The regular monthly meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the William Penn Hotel, Tuesday, January 22nd at 4:40 P. M., President Morris Knowles presiding, Messrs. Crabtree, Spellmire, Hobbs, Leland, James, Ladd, Braden, Goodspeed and the Secretary being present.

The Minutes of the last regular meeting held December 11th, were approved without reading.

Applications for membership from the following gentlemen, having been published to the Society in accordance with action of the Board, were elected to membership:

MEMBERS

Hiller, August
Houssman, John
Mechesney, Charles Armstrong
Millard, Emmor Hamilton
Walker, James Blair

ASSOCIATE MEMBERS

Crowder, R.
McMahon, James Joseph

JUNIORS

Witney, William Leslie

Applications for membership were received from the following gentlemen and their names ordered published to the Society. Assignment to the various grades of membership is as follows:

MEMBERS

Alexander, J. Irvin
Allan, David Wylie
Bartholomew, Tracy
Brooks, Henry Warren
Downes, Henry Hackett
Gill, David Donald
Grobstein, Albert
Hansen, Wm. Charles
Horner, Ralph B.
Johnson, Arthur B.
Mitchell, Robert Augustus
Morgan, Edward Frederick
Morrison, George William
Orr, Thomas Edwin
Owen, John Emlyn
Porter, Rudyard
Reed, Louis Jerome
Savage, Luke Francis

ASSOCIATE MEMBERS

Monk, P. S.
Ruos, Henry Danz, 2nd
Wilson, Dean R.

JUNIORS

Rixmann, C. L.
Stalker, Dwight T.

Letters were received from the following asking that they be reinstated to membership and after discussion, the Secretary was requested to write them advising that they had been again placed on the Society Rolls.

J. A. Partington
W. R. Work

The Secretary reported the death of the following members:

E. C. Dilworth, Joined March, 1923, Died Dec. 24, 1923.
D. T. Wadsworth, Joined Sept. 1923, Died Dec. 20, 1923.
Wm. Hoopes, Joined March, 1913, Died Jan. 9, 1924.
J. R. Hammond, Joined June, 1923, Died Jan. 7, 1924.

It was moved and carried that the Secretary write Mr. Roy Hunt asking him to prepare a memoir of Mr. Hoopes. It was suggested further that Mr. Hunt might use the memoir prepared by Mr. Fickes as a basis.

The report of the Secretary showing the financial condition of the Society at the close of business Dec. 31st, having been previously audited by the Finance Committee, was approved.

Mr. Hobbs, Chairman of the Entertainment Committee, reported a deficit of $92.85 for the entertainment given Friday evening, November 17th. He further reported that reservations for the Annual Banquet indicated that we were going to have the largest attendance in the history of the Society.

Mr. Leland, Chairman of the House Committee, reported on the work done by the Committee during the year, advising the Chess Tournament was held and the winners Mr. Leland and Mr. Stucki, receiving first and second prizes, which were presented by Messrs. Wm. F. Hall and L. C. Frohreib. The lease was renewed for another year at the same rental. The evening attendance for 1923 was 823 over the previous year, that for 1923 being 2319 and that for 1922, 1496.

Mr. Spellmire, Chairman of the Membership Committee, reported that one meeting had been held to assign applications received since the last meeting of the committee, also to act upon resignations received.

Mr. Crabtree, Chairman of the Publication Committee, stated that the committee had nothing of special interest to report other than that the program as arranged by the committee gave promise of being carried out as scheduled.

The Secretary presented a letter from Mr. E. A. Holbrook, Chairman of the Mining Standards Committee of the American Mining Congress, stating that sectional committees were being formed on Mine Ventilation, Underground Transportation, Underground Power Transmission and Power Equipment, Mine Drainage, and asked our organization if we would be interested in appointing a representative to act on any or all of these committees. After discussion it was moved and carried that this matter be referred to the Civic Affairs Committee.

The meeting adjourned at 5:40 P. M.

K. F. Treschow,
Secretary.

ANNUAL MEETING

The Forty-Fourth Annual Meeting of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, January 15th, at 8:08 P. M., President Morris Knowles presiding, 74 members and visitors being present.

The Minutes of the last Annual meeting held January 16th were read and approved.

The Annual Report of the Board of Direction, which included the reports of the Standing and Special Committees, the Sections and the Treasurer, were read as follows:

REPORT OF BOARD OF DIRECTION

The Board of Direction held ten regular and two special meetings during the year, at which routine business of the Society was transacted.

During the year there were nine regular and the Annual meeting of the Society. The total attendance was 654, the average being 65. The maximum attendance was 94 at the March meeting and the minimum 29 at the February meeting. The average number participating in the discussion was seven.

At the close of the year, the membership of the Society was as follows:

Honorary Members	1
Members	1099
Associate Members	100
Associates	34
Juniors	72
Student Juniors	3
Total	1309
Dropped	63
Resignations	53
Removed by death	9
	125
Accessions	99

Respectfully submitted,

K. F. Treschow,
Secretary.

REPORT OF ASSOCIATED ENGINEERING SOCIETIES OF PITTSBURGH GOVERNING COUNCIL

To the Board of Direction,
Engineers' Society of Western Pennsylvania.
Dear Sirs:

Five meetings of the Governing Council were held during the year 1923 to take up questions of interest to the engineering profession.

1. Meeting called to act upon resolution passed by the Practising Engineers' Section of the Society, expressing censure and dissatisfaction over

administration of the law licensing engineers by the Registration Board. The subject was tabled.

2. Communication received from Joint Planning Commission, asking the approval of Council of its request to County Commissioners for an appropriation of $25,000 for basic survey, inasmuch as the City had a like appropriation. In making this triangulation survey, it would be necessary to cover the entire county to make the work of any value and would be more economical to make the surveys at one time. The Secretary was requested to draft a resolution to the County Commissioners urging their approval of this appropriation.

3. Approval of Resolution now before Congress (S. J. Res. 209) to establish a National Hydraulic Laboratory. Question referred to individual organizations with request that the Secretary of Council secure literature for the use of member organizations.

4. Zoning Ordinance. It was moved and carried that recommendation be made to City Council that it pass the Zoning Ordinance and that the present ordinance be referred back to the individual societies for their investigation and action.

5. Repeal of Bill Licensing Engineers and Land Surveyors in the State of Pennsylvania. Question referred to Governing Council by the Pittsburgh Section, A. S. C. E., Practising Engineers' Section of Engineers' Society of Western Pennsylvania and Engineers' Club of Philadelphia. Subject was tabled.

6. Engineers to cast their vote. Meeting called at the suggestion of several engineers suggesting that notice be sent to members of various organizations calling attention to their duty as citizens and urging that they register and vote at the coming election. Recommendation made that each constituent body send such notice to its members and the Secretary instructed to forward this information to various secretaries.

7. Rebuilding of 6th, 7th, and 9th St. bridges, which County Commissioners were considering awarding to architects. Chairman had taken subject up with Commissioners, protesting against awarding contract to architects. Letter written by Chairman and letter approved by Council.

8. Re: Invitation to Pittsburgh Chapter, American Association of Engineers to become a member of this body. Secretary requested to secure list of members and as soon as secured, meeting to be called for consideration. Meeting called and Chairman requested to interview officers of organization and ascertain if they desired to join the organization and have two members of their association appointed on the Governing Council.

Chairman did so, and no answer received.

Respectfully submitted,

MORRIS KNOWLES,
Chairman.

REPORT OF CIVIC AFFAIRS COMMITTEE

To the BOARD OF DIRECTION,
Engineers' Society of Western Pennsylvania.

DEAR SIRS:

Eleven meetings of the Committee were held during the year 1923 to take up matters referred to them by the Board of Direction. The various questions taken up by the Committee were:

1. Zoning Ordinance: The Zoning Ordinance for Pittsburgh was approved as prepared by the Department of City Planning, with the exception of "Heights of Buildings", which it was recommended to be corrected as follows: "Section 23—Maximum Height District. In this district the height shall be limited to one hundred and twenty-five (125) feet when the building abuts on a street fifty (50) feet wide or less; when the building abuts on a street more than fifty (50) feet wide, the maximum height may be two and a half (2½) times this width, but not exceeding one hundred and eighty (180) feet. Additional stories may be added, provided that above such heights, fixed by the above limitations no point in the wall of any frontage of the building shall be nearer to the vertical plane through any street line than a distance equal to one-half the height of such point above the limiting heights fixed above, and provided such extra height shall not exceed the width of the widest street upon which the building abuts, and provided further that no dwelling, except a hotel, shall exceed the height limits limitation prescribed above for the seventy-five (75) foot district. (See Sections 21, 26, 27, 28 and 29).

2. St. Lawrence River Developments. Referred to Committee by the Board of Direction. Committee recommended that it be referred to the Governing Council of the Associated Engineering Societies of Pittsburgh as they believed this was a National problem, not a local one.

3. Rebuilding of 6th, 8th and 9th Street Bridges. Recommendation made that resolution be passed that County Engineer be placed in charge of this work and that he secure such consultants of experience as he may deem necessary to take care of architectural features. Also approved by Municipal Affairs Committee of Pittsburgh Chapter, American Institute of Architects who held a joint meeting with the Committee.

4. House Bill No. 611. Repealing Special Act of 1870 which was enacted to keep County Engineer's office entirely free from political influence. Committee recommended that we write the Governor asking that he veto the bill. Recommended that we write the various engineering societies asking that they take similar action.

5. Notice to membership to vote. Meeting called to consider recommendation of the Governing Council of the Associated Engineering Societies of Pittsburgh, suggesting that notice be sent to the membership reminding them of their duty to cast their vote at the coming election. Approved and referred to Board of Direction.

6. Removal of A. P. Davis from Reclamation Service. Recommendation made by the Committee that letters be sent to the Hon. Hubert S. Work, Secretary of the Interior and the two Senators from Pennsylvania protesting against his removal.

7. Membership in Chamber of Commerce. The Committee made the recommendation to the Board of Direction that a membership should be taken out in the Chamber of Commerce in the name of the Secretary of the Society.

8. Reappointment of County Engineer's Office. The Committee recommended to the Board of Direction that the Society make proper recommendation to the County Commissioners in re the appointment of a county engineer, i. e., other things being equal, the long experience of the present incumbent in the duties of this office should be given proper consideration.

Respectfully submitted,

RICHARD KHUEN, JR.,
Chairman.

REPORT OF HOUSE COMMITTEE

To the Board of Direction,
Engineers' Society of Western Pennsylvania.

Dear Sirs:

The House Committee beg to report on the work done during the year 1923 as follows:

A petition signed by twenty-two members asked that a Bridge Tournament be held, which was approved by the Board.

The usual Chess Tournament was held, the winners being Mr. E. D. Leland receiving the first prize and Mr. A. Stucki the second. The prizes were presented by Messrs. Wm. F. Hall and L. C. Frohrieb.

The lease for our quarters in the William Penn Hotel was renewed for another year at the same rental.

There has been an increase in the evening attendance for the year 1923 over that of the previous year of 823, the 1923 attendance being 2319 and the 1922 attendance being 1496.

Respectfully submitted,

E. D. Leland,
Chairman.

ENTERTAINMENT COMMITTEE

To the Board of Direction,
Engineers' Society of Western Pennsylvania.

Dear Sirs:

The Entertainment Committee report the following activities for the fiscal year:

March 24th, Inspection trip, Attendance 185. Liberty Tunnels.

April 14th, Inspection trip, Attendance 128. Power Plant, West Penn Power Co., Springdale, Pa.

May 11th, Entertainment, Attendance 250. Engineers' Night, Dramatic Arts Department, Carnegie Institute of Technology. Red Turf—The Turn of the Road.

June 2nd, Inspection trip, Attendance 105. National Works, National Tube Co., McKeesport, Pa.

Sept. 28th, 29th, 30th, Inspection trip, Attendance 84. Plants Ford Motor Co. and Detroit-Edison Co., Detroit.

Dec. 1st, Inspection trip, Attendance 54. American Zinc & Chemical Co., Langeloth, Pa.

Dec. 17th, Ladies' Night, Attendance 135. Entertainment and dance, Blue Room, William Penn Hotel.

Jan. 28th, Annual Banquet. Arrangements have been completed for the Annual Banquet and reservations are coming in rapidly.

Respectfully submitted,

J. C. Hobbs,
Chairman.

FINANCE COMMITTEE REPORT

To the Board of Direction,

Engineers' Society of Western Pennsylvania.

Dear Sirs:

Your Finance Committee wishes to report on the financial condition of the Society at the close of business December 31, 1923, as follows:

The budget of receipts estimated by the Committee the first of the year was 21,031.00; actual receipts were $24,186.88, making an excess of receipts of $3,155.88. Over $2,000.00 of this increase is due to advertising secured and the balance to increased sales of Proceedings and receipts on our annual banquet.

The estimated budget for expenditures was set at $19,037.00. Actual expenditures were $19,417.72, making an excess of $380.72. $188.00 of this excess was due to reprints from the Proceedings on which we realized the same amount and the balance was due to the cost of our year book.

On January 1, 1923, we had on hand unpaid bills amounting to $1,740.68 and a note payable for $1,500.00. These bills, as well as the note have been paid and we closed this year with but $3.05 in unpaid bills.

On January 1, 1923 we had a deficit in our Permanent and Reserve Funds of $8,945.00. Through the generosity of the industries of Pittsburgh, we have been able to pay off $4,900.00 of this deficit and we have $2,700.00 more in sight. The Committee believes that this deficit can be entirely wiped out within the next few months.

One of the first recommendations of this committee was that the advertising be taken out of the hands of outside advertising solicitors and placed in charge of the Secretary and that an assistant be placed in the office to relieve the Secretary of some of the detail work in order to give him an opportunity to secure more advertising for the Proceedings. On December 31, 1922, the total avertising amounted to $2,891.00. On December 31, 1923 it amounted to $4,979.00, a net increase during the year of $2,088.00, and since this date $320.00 additional advertising has been secured. The net cost to the Society of the Proceedings for 1923 was $586.81 as against $3,456.21 in 1922. The total cost of Proceedings for 1923 was $5,032.80, which, with the total advertising on our books as of January 1st, 1924, amounting to $4,979.00, means that in securing one more page advertising, our Proceedings will be on a self supporting basis for the first time in the history of the Society. In other words, for the present the Society should maintain an average income from its advertising of at least $6,000.00 per year to break a little better than even on the transactions.

It might be well, however, to call attention to the fact that while the increase in dues will partly take care of the deficit we have had in recent years, it is absolutely essential that we keep our Proceedings on a self-ssupporting basis by keeping our advertising up to its present mark. Without our advertising we would still find it difficult to make our accounts balance.

On January 1, 1923 in accordance with a letter ballot taken the previous Fall the dues were increased to $15.00. It will probably be of interest to the members to know that practically no resignations were received due to this increase.

Entrance Fees received during the year 1923, amounting to $710.00, have been deposited in the Permanent Fund in accordance with the By-Laws. This means that with all bills paid to December 31st, the Society starts the year 1924 with a clean slate.

In conclusion I wish to thank the members of my committee, Messrs. Humphrey, Allderdice, Coolidge and Fohl, together with the Secretary of the Society, Mr. Treschow, for their kind and hearty cooperation.

Respectfully submitted,

GEORGE T. LADD,
Chairman.

REPORT OF MEMBERSHIP COMMITTEE

To the BOARD OF DIRECTION,
Engineers' Society of Western Pennsylvania.
DEAR SIRS:

The Membership Committee is pleased to report on work done during the year 1923. Monthly meetings of the Committee were held to discuss ways and means of increasing the membership, also to pass on applications received, assigning them to the various grades of membership and act on resignations.

All reasonable steps were taken to attract desirable members. Among many of the important industrial concerns, members of the Society were designated to secure engineer society members in their company. Much work was done by personal solicitation of the Membership Committee.

Following a plan previously carried out, a list of about 50 names was prepared covering executives of high standing in this industrial community, who by virtue of their relation as chief executives of large industrial engineering concerns constitute desirable members. It was recommended to the Board of Direction that engraved invitations be sent to these executives, thereby permitting them to become members without filling in the regular application form.

Results of the work of the Committee for 1923 and 1922 are shown as follows:

	1923	1922
Honorary Members	0	0
Members	54	62
Associate Members	28	14
Associates	5	6
Juniors	10	14
Student Juniors	1	0
Reinstatements	1	8
	99	104
Dropped	63	37
Resignations	53	49
Deaths	9	8
	125	94
Accessions	99	107

The membership of the Society as of December 31, 1923 and 1922 is as follows:

	1923	1922
Honorary Members	1	1
Members	1099	1129
Associate Members	100	92
Associates	34	32
Juniors	72	80
Student Juniors	3	1
	1309	1335
Dropped	63	37
Resignations	53	49
Deaths	9	8
	125	94
Accessions	99	107

In making comparison of this year and last, it should be noted that this year 63 members were dropped in contrast to 37 dropped the previous year. Further it was during the year 1923 that the dues were increased, which offered resistance to increase in membership, also during 1922 there were eight more reinstatements to only one during 1923.

I am glad to have this opportunity of thanking the committee for the valuable assistance rendered, also the Secretary for his very helpful co-operation.

Respectfully submitted,

W. B. Spellmire,
Chairman.

PUBLICATION COMMITTEE REPORT

To the Board of Direction,
Engineers' Society of Western Pennsylvania.
Dear Sirs:

During the year 1923 the Committee held two meetings with an average attendance of four.

Papers presented at the regular Society meetings 10

Papers presented at various Section meetings 16

Two meetings of the Practising Engineers' Section were held for discussing the business of the Section, one paper being presented at these meetings.

Fifteen of the above papers presented have been published in the Proceedings of the Society or will appear in later issues.

The publication of the Proceedings is now up to date.

Respectfully submitted,

Frederic Crabtree,
Chairman.

TREASURER'S REPORT

To the Board of Direction,
Engineers' Society of Western Pennsylvania.
Dear Sirs:

Your Treasurer desires leave to submit the following report for the year 1923:

RECEIPTS

Dues collected	$15,511.26	
Entrance Fees	710.00	
Sale of Advertising	4,173.39	
Sale of Proceedings	886.60	
Sale of Society Pins	78.00	
Interest on Bonds	690.00	
Interest on Bond Balances	126.17	
Income from Banquet	5,803.00	
Sale of Inspection Trip Tickets	1,717.69	
From Practising Engineers' Dinner	56.00	
Ladies' Night Entertainment	200.00	
Sale of Furniture	10.00	
Miscellaneous	27.77	
Total Receipts	$29,989.88	$29,989.88

DISBURSEMENTS

Administrative in General	$14,320.35	
Cost of Proceedings	6,628.74	
Ladies' Night Entertainment	289.00	
Inspection Trips	2,091.21	
Annual Banquet 1923	5,164.84	
Annual Banquet 1924	215.63	
Miscellaneous Expenditures	76.90	
Total Disbursements	$28,786.67	$28,786.67

CASH ASSETS

	Dec. 31, 1922	Dec. 31, 1923
Permanent Fund		
Bonds	$12,730.00	$13,303.75
Cash (Fidelity T. & T. Co.)	194.71	1,904.71
Reserve Fund		
Cash (Fidelity T. & T. Co.)	100.00	2,500.00
General Fund		
Cash (First National Bank)	255.50	848.71
	$13,280.21	$18,557.17
Increase in Assets	5,276.96	
	$18,557.17	$18,557.17

BONDS OWNED PERMANENT FUND

One One Thousand Dollar Butler Water Co., 5% bond No. 9 Maturing Sept. 2, 1931	$ 850.00
Two One Thousand Dollar Connellsville Water Co., 5% Nos. 317-318 Maturing Oct. 1st, 1930	1,700.00
Two One Thousand Dollar Porstmouth Berkley & Suffolk Water Co., 5%, Nos. 465-66 Maturing Nov. 1, 1944	1,800.00
Two One Thousand Dollar Jamison Coal & Coke Co., 5% Nos. 1502-1503 Maturing Nov. 1, 1931	2,000.00
Two One Thousand Dollar Union Steel Co., 5% Nos. 38642-38643 Maturing Dec. 1, 1952	2,080.00
Two One Thousand Dollar Pennsylvania R. R. Co., 4½% Nos. 27320-27321, Maturing Aug. 1, 1960	1,892.50
Three One Thousand Dollar Jones & Laughlin Steel Corp., 5% Nos. 3020-3021-3022, Maturing May 1, 1931	2,981.25
Total	$13,303.75

It will be noted that our bonds have increased in value $573.00 during the past year.

We have increased our assets $5,276.96 this year, which leaves a deficit in our Permanent Fund of about $4,000.00. However, as pointed out by Mr. Ladd in his report, we believe that this will be wiped out within the next few months. I wish to take this opportunity of thanking the following companies for coming to our aid with contributions to wipe out the deficit accumulated during the past three years in our working capital: American Sheet & Tin Plate Co., American Steel & Wire Co., Armstrong Cork Co., Carnegie Steel Co., Fort Pitt Malleable Iron Co., Jones & Laughlin Steel Corp., The Koppers Co., Philadephia Co., National Tube Co., Westinghouse Air Brake Co., Westinghouse Elec. & Mfg. Co., Firth-Sterling Steel Co., Allegheny Steel Co., and the H. C. Frick Coke Co.

The Society closed the year with a balance of $800.00 in the General Fund, with all bills paid, which permits us to start the year 1924 with a clean slate.

Respectfully submitted,

A. Stucki,
Treasurer

REPORT OF CIVIL SECTION

To the Board of Direction,
Engineers' Society of Western Pennsylvania.

Dear Sirs:

I beg to submit the report of the work done by the Civil Section during the year 1923.

Four regular meetings of the Section were held during the year. The average attendance at these meetings was 91, the maximum being 101 at the January meeting and the minimum 82 at the May meeting.

An average of seven participated in the discussion of the several papers presented. The papers presented were:

January 9th—Annual Meeting. "Concrete Pipe—Plain and Reinforced," by Joseph S. Lambie, Associate Professor, Civil Engineering, University of Pittsburgh.

May 1st—"The Bates Test Road," R. R. Benedict, Chief Prin. Asst. Engineer, Dept. Public Works & Buildings, States of Illinois, Springfield, Ill.

September 11th—"Concrete Piles and Concrete Piling Construction," by Maxwell M. Upson, V. P. & Gen. Mgr., Raymond Concrete Pile Co., New York City, N. Y.

November 13th—"The Erection of the Southern Railroad Bridge Over the Ohio River at Cincinnati," by Frederick W. Henrici, Assistant Engr., Erecting Department, American Bridge Co., Pittsburgh, Pa.

Respectfully submitted,

B. A. Ludgate,
Chairman.

REPORT OF MECHANICAL SECTION

To the Board of Direction,
Engineers' Society of Western Pennsylvania.
Dear Sirs:

I beg to submit the report of the work done by the Mechanical Section during the year 1923 as follows:

Five regular meetings of the Section were held during the year. The average attendance at these meetings was 78, the maximum being 172 at the June 5th meeting and the minimum 32 at the February meetings.

An average of 5 participated in the discussion of the several papers presented. The papers presented were:

February 13th—Annual meeting. Address on "Metallurgy," Walter Rosenhain, A. B., Sc. D., F. R. S., Superintendent, Metallurgical Department, National Physical Laboratory, Teddington, England.

April 3rd—"Recent Developments in the Field of the Air Cooled Motor," by Mr. Louis Stellman, Chief Engr., H. H. Franklin Mfg. Co., Syracuse, N. Y.

June 5th—"Pulverized Fuel for Boilers," by J. C. Hobbs, Mgr., Allegheny County Steam Heating Co., and L. W. Heller, General Superintendent, Power Stations, Duquesne Light Co.

October 9th—"The Relations Between the Engineering and Operating Departments," by F. J. Crolius, Editor, Blast Furnace and Steel Plant.

December 4th—"Modern Methods of Bolt and Nut Manufacture," by W. B. Peirce, Works Mgr., Graham Bolt & Nut Co., Coraopolis, Pa.

Respectfully submitted,

E. P. Dandridge,
Chairman.

REPORT OF MINING SECTION

To the Board of Direction,
Engineers' Society of Western Pennsylvania.
Dear Sirs:

I beg to submit the report of work done by the Mining Section during the year 1923.

Five regular meetings of the Section were held during the year. The average attendance at these meetings was 43, the maximum being 67 at the October meeting, and the minimum 29 at the May meeting.

An average of five participated in the discussion of the several papers presented. The papers presented were:

January 30th—Annual Meeting. "The Application of Fans to the Ventilation of Mines," by J. R. Robinson, President, Robinson Ventilating Co., Pittsburgh, Pa.

March 27th—"Present Practice in the Design and Sinking of Mine Shafts," by R. G. Johnson, President, R. G. Johnson Co., Pittsburgh, Pa.

May 29th—"The Problem of Corrosion in the Mining Industry," by George M. Enos, U. S. Bureau of Mines, Pittsburgh, Pa.

October 30th—"Thick Freeport Coal," by J. M. Rayburn, Civil and Mining Engineer, Pittsburgh, Pa.

December 18th—"A New Belgian Process of Washing Coal— the 'Rheolaveur'," by Y. Kersten and A. Andry, Belgian Mining Engineers, Brussels and Liege, Belgium.

Respectfully submitted,

HOWARD N. EAVENSON,
Chairman.

REPORT OF PRACTISING ENGINEERS' SECTION

To the BOARD OF DIRECTION,
Engineers' Society of Western Pennsylvania.
DEAR SIRS:

I beg to submit the report of work done by the Practising Engineers' Section during the year 1923.

Two meetings of the Section were held during the year. The average attendance at the meetings was 61, 42 attending the May 8th meeting and 19 attending the February 21st meeting.

The regular business of the Section was taken up at the February 21st meeting and the meeting of May 8th the following paper was presented.

"Architecture from an Architect's Viewpoint," by William Boyd, Ingham & Boyd, Architects, Pittsburgh, Pa.

Respectfully submitted,

P. H. MARTIN,
Chairman.

REPORT OF STEEL WORKS SECTION

To the BOARD OF DIRECTION,
Engineers' Society of Western Pennsylvania.
DEAR SIRS:

I beg to submit the report of the work done during the year 1923 by the Steel Works Section.

Two meetings of the Section were held during the year. The average attendance at these meetings was 59, the maximum being 67 at the April 24th meeting and the minimum being 51 at the September 18th meeting.

An average of 8 participated in the discussion of the papers presented. The papers presented were:

April 24th—Annual Meeting. "Water Deactivation," by F. N. Speller, Metallurgical Engr., National Tube Co., Pittsburgh, Pa.

Sept. 18th—"Reactivity of Coke in Relation to Blast-Furnace Operation," by George St. J. Perrott, Assistant Physical Chemist, and Ralph S. Sherman, Assistant Physicist, U. S. Bureau of Mines, Pittsburgh, Pa.

Respectfully submitted,

G. M. Goodspeed,
Chairman.

REPORT OF TELLERS

To the Members:

Engineers' Society of Western Pennsylvania.

Dear Sirs:

The undersigned tellers publicly canvassed the ballots in the annual election of officers of the Society at noon, Tuesday, January 22nd, 1924 and wish to report the following:

Ballots received	374
Irregular ballots	2
Ballots counted	372

For President—Frederic Crabtree	372
For Vice President—W. E. Fohl	370
For Treasurer—A. Stucki	364
For Directors—G. M. Goodspeed	366
W. A. Weldin	364

Respectfully submitted,

Chas. A. Carpenter, *Chairman,*
A. G. McGarvey,
H. A. Ingram,
Tellers.

The President thereupon declared the following gentlemen elected:

For President .....Frederic Crabtree
For Vice President .....W. E. Fohl
For Treasurer .....A. Stucki
For Directors G. M. Goodspeed and W. A. Weldin .....

President Knowles appointed Past Presidents W. C. Hawley and J. O. Handy to escort the president elect to the chair and addressed the meeting as follows:

"This presentation of your President Elect is an interesting episode in the lives of two old friends. A little personal history may not be amiss and may be of interest. This is not a story of a fancied wrong and opportunity for revenge, nor occasion to heap coals of fire on the head, but it is rather the tale of the elder brother, always the helper, now to be the recipient.

"Two boys in a textile town in New England were in high school together, the elder preceding the younger by two years. Later they were fellow students at Boston Tech, commuting together the 54 miles each day and thus continued their intimate acquaintance. The elder always gave freely from his greater experience the counsel and advice which is always so helpful to the youngster in getting over hard places in lessons and

sometimes when studies did not press too hard, there was a game of chess while traveling, using a pocket folder for a continuous record. This interesting memoranda is still preserved by the younger as a reminder of school days. These two boys were Fred Crabtree and myself. Upon coming to Pittsburgh 27 years ago, I found that Fred had preceded me and was engaged as a Chemist at the National Tube Co. Then, as now, many technically trained men of the district were employed in the steel mills. I still remember the first Sunday spent here with his family in McKeesport and how enjoyable it seemed to meet New England friends.

"While we have both been away from Pittsburgh at times for longer or shorter intervals, this city has been our abode for many years and for a long time both have been interested in the Engineers' Society of Western Pennsylvania. By some fortuitous circumstances it fell to the lot of the younger to be first chosen by your ballots to be a Director and gradually promoted to be President of this great Society. He now finds himself in the happy position of being able to turn the tables upon the elder and in reciprocation of his many acts of kindness to now act as the giver.

"Fred, it gives me great pleasure to hand to you this gavel as the emblem of the office and authority as President of the Engineers' Society of Western Pennsylvania. We little thought a third of a century ago that fate would have this in store for us and it is doubtful if our parents, in their fondest dreams of success for their children, could ever have anticipated this occasion. In giving you this gavel with my very best wishes, it is with the earnest hope that you have the same loyal service that I have enjoyed from the officers and our fellow members of this Society."

Mr. Crabtree addressed the meeting as follows:

Gentlemen, I cannot but feel very deeply the great honor you have conferred upon me in electing me your president for the current year. Also I have a very oppressive feeling of responsibility when I think of the exceptionally able and distinguished men who have preceded me in this office. When we remember that the ever growing importance of the engineer in our community life and in our national life we are bound to recognize the fact that it is a very distinguished honor to be president of such a Society. And, of course, with the honor there must go a very great responsibility.

I do not wish to take up your time this evening. A long time has been required to transact the regular business of this evening, with all the annual reports of committees and especially since we are to have the address of the retiring president, it is very undesirable for me to take up any more time. I do want to assure you that I shall do my very best to approach the spirit and the efficiency achieved by my predecessors in office. I can hardly hope to equal them but I assure you I shall try just as hard as I can to do it."

No further business coming before the Society, the retiring President's address was presented by Mr. Morris Knowles on "The Engineer of Today and His Responsibility."

The President announced the new Committee Chairmen as follows:

Richard Khuen, Jr., ...Civic Affairs
J. C. Hobbs.....Entertainment
W. E. Fohl.....Finance
E. D. Leland .....House
W. B. Spellmire.....Membership
G. M. Goodspeed.....Publication

On motion the meeting adjourned at 9:50 P. M.

K. F. Treschow,
Secretary.

CIVIL SECTION—ANNUAL MEETING

The Annual meeting of the Civil Section of the Engineers' Society of Western Pennsylvania was held in the Hawaiian Room, William Penn Hotel, Tuesday, January 8th, at 8:10 P. M., Chairman B. A. Ludgate presiding, 148 members and visitors being present.

The Minutes of the last Annual meeting were read and approved.

The Annual report of the Section was read by the Secretary.

The report of the Nominating Committee was read by Mr. N. F. Hopkins, as follows:

OFFICERS AND MEMBERS OF THE CIVIL SECTION,
Engineers' Society of Western Pennsylvania.
DEAR SIRS:

Your Nominating Committee appointed to nominate officers for the Section for the year 1924 held a meeting and give below the following report.

E. V. Braden.....Chairman
C. C. Dornbush.....Vice Chairman
W. H. Buente.....
J. T. Campbell.....
V. R. Covell.....
C. S. Davis.....
F. M. McCullough.....
} Directors

Respectfully submitted,

R. P. FORSBERG, *Chairman,*
N. F. HOPKINS,
PARK H. MARTIN,
Nominating Committee.

On motion the nominations were closed and the Secretary instructed to cast a unanimous ballot in favor of the officers named and they were, therefore, declared elected.

There being no further business, the meeting adjourned and the regular bi-monthly meeting was called to order by the new chairman, E. V. Braden.

The Minutes of the last bi-monthly meeting held November 13th were read and approved.

There being no further business coming before the Section, the paper of the evening on "Selection of Sand and Gravel for Concrete in the Pittsburgh District was presented by Mr. Charles M. Reppert of Brown & Reppert, Inc., Pittsburgh, Pa.

Formal discussion was presented by:

"Production of River Sand and Gravel," A. W. Dann, V. P. and Treas., Keystone Sand & Supply Co.; "Tests to Determine Suitability of Sand and Gravel," P. J. Freeman, Consulting Engineer; "Characteristics of Local Aggregates and Methods of Testing Concrete and Concrete Materials," J. J. Paine, Director, Bureau of Tests, City of Pittsburgh; "Municipal Practice," F. W. Lyon, Chief Engr., Bureau of Engineering, Dept. of Public Works; "Control and Records of Concrete Construction," J. D. Stevenson, Asst. Chief Engr., Bureau of Engineering, City of Pittsburgh.

The ensuing discussion was participated in by: E. V. Braden, Engr., Pittsburgh, Chartiers & Youghiogheny Rwy. Co.; C. S. Davis, Cons. Engr., Pittsburgh, Pa.; J. M. Dilley, Field Repr., Portland Cement Association;

P. J. Freeman, Cons. Engr.; C. N. Haggart, Struct. Engr.; Jos. Lambie, Assoc. Professor, Civil Engrg., University of Pittsburgh; J. P. Leaf, City & Cons. Engr., Rochester, Pa.; F. M. McCullough, Professor, Civil Engrg, Carnegie Institute of Technology; P. W. Price, Asst. Engr., County Engineer's Office; T. J. Wilkerson, Cons. Engr., Beaver Falls, Pa.; and the authors.

A motion was made that the Chairman appoint a Committee of three men, who will investigate the feasibility of recommending to the manufacturing people around the city the use of larger sized sand— ⅜ instead of ¼. It was recommended that if this committee is formed, the committee study the whole question of concrete aggregates and make other recommendations along the lines indicated in regard to sand and gravel, in a general way. It was also recommended that the Committee be enlarged so that a complete study of the subject could be made, with a view to putting out recommendations for general specifications for use. The Chairman stated he would take the matter up with the Board of Direction to secure their approval of the appointment of such a committee.

It was moved and carried and passed unanimously that the above recommendation be carried out.

The meeting adjourned at 11:05 P. M.

K. F. Treschow,
Secretary.

BOARD OF DIRECTION

The regular monthly meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the William Penn Hotel, Tuesday, February 12, at 4:40 P. M., President Crabtree presiding, Messrs. Spellmire, Fohl, Stucki, Leland, Khuen, Goodspeed, Weldin, James, Braden, Buell, Eavenson and the Secretary being present.

The minutes of the last meeting, held January 22, were approved without reading.

Applications for membership from the following gentlemen, having been published to the Society in accordance with the action of the Board, were elected to membership:

MEMBERS

Alexander, J. Irvin
Allan, David Wylie
Bartholomew, Tracy
Brooks, Henry Warren
Downes, Henry Hackett
Gill, David Donald
Grobstein, Albert
Hansen, William Charles
Horner, Ralph B.
Johnson, Arthur B.
Mitchell, Robert Augustus
Morgan, Edward Frederick
Morrison, George William
Orr, Thomas Edwin
Owen, John Emlyn
Porter, Rudyard
Reed, Louis Jerome
Savage, Luke Francis

ASSOCIATE MEMBERS

Monk, P. S.
Ruos 2nd, Henry Danz
Wilson, Dean R.

JUNIORS

Rixmann, C. L.
Stalker, Dwight F.

Applications for membership were received from the following gentlemen and their names ordered published to the Society. Assignment to the various grades of membership is as follows:

MEMBERS

Barry, Thomas J.
Binnall, Frederick Clifford
Erichson, William B.
Freeman, P. J.
Holmes, Hugh B.
Jones, David Guy
Jordan, Edward Henry
Magill, F. R.
Zimmerman, R. E.

ASSOCIATE MEMBERS

Daniel, T. L.
McKinley, Arch
Spain, Batt L.
Van der Kloet, Mark
Wilson, Joseph Charles, Jr.

Application for reinstatement was received from Mr. L. F. Crawford and, after discussion, the Secretary was requested to write him stating that he had again been placed on the Society rolls.

Applications for transfer were received from the following, and they were transferred to the grades noted:

Barnsley, George T., Jr.....Associate Member
Johnson, Carl Emil .....Member
Ross, Theodore H .....Member

In regard to the resignation of Mr. W. M. Judd, it was moved and carried that in view of Mr. Judd's long and active membership in the Society

and to the interest he has always shown in our work, the Secretary be instructed to write him asking his permission to continue his name on the rolls with the understanding that all future dues be remitted.

The Secretary reported the death of Mr. A. L. Hoerr, who joined the Society in February, 1903, and died January 28, 1924. It was moved and carried that a committee be appointed to prepare a memoir of Mr. Hoerr, the committee being composed of G. M. Goodspeed, Chairman, and W. A. Cornelius and L. J. Affelder.

The report of the Secretary showing the financial condition of the Society at the close of business January 31, having been audited by the Finance Committee, was approved.

Mr. Khuen, Chairman of the Civic Affairs Committee, announced the appointment of the following committee: J. Toner Barr, L. P. Blum, Thomas Fleming, Jr., R. P. Forsberg, James O. Handy and W. E. Mott.

In the absence of Mr. Hobbs, Chairman of the Entertainment Committee, the Secretary reported that the members of last year's committee had been reappointed to serve this year.

Mr. Leland, Chairman of the House Committee, reported an evening attendance of 297 for the month of January. Announcement was also made of the reappointment of Mr. L. C. Frohrieb and Mr. William F. Hall to serve on the committee.

Mr. Spellmire, Chairman of the Membership Committee, reported that one meeting of the committee had been held to go over applications received and act upon resignations. The following men were appointed to serve on the committee for the ensuing year: P. Caldwell, J. L. de Vou, J. S. Fulton, W. R. Jarvis, T. H. McGraw, Jr., G. M. Quentin, E. Rahm, Jr., W. B. Skinkle, G. E. Stoltz and T. H. Ross.

Mr. Goodspeed, Chairman of the Publication Committee, announced the appointment of his committee as follows: Norman Allderdice, G. M. Baker, E. V. Braden, G. D. Bradshaw, W. C. Buell, Jr., J. B. Crane, A. E. Crockett, L. B. Duff, H. S. Harrop, F. E. Leahy and F. A. McDonald.

Mr. Fohl, Chairman of the Finance Committee, announced the appointment of the following men to serve on the committee for the year: Taylor Allderdice, Graham Bright, N. F. Brown, T. J. Gillespie, Jr., A. L. Humphrey and F. J. Lanahan.

He further reported that a meeting had been held to consider the preparation of a budget of expenditures and receipts for the year, and respectfully present the following:

Receipts		Expenditures	
Advertising	$ 4,775.00	Rent	$ 3,600.00
Dues	16,000.00	Salaries	7,060.00
Sale Proceedings	400.00	Proceedings Ptg. and Cuts	3,500.00
Interest	800.00	Year Book	525.00
Profit on Banquet	445.00	Miscellaneous Printing	1,600.00
Society Pins	100.00	Postage	1,000.00
		Advertising Solicitor	270.90
		Office and Miscellaneous	1,000.00
		Entertainment	500.00
		Editorial Expense	450.00
		Reporting Meetings	450.00
		Year Auditing	225.00
		Addressograph Machine	280.00
		Motion Picture Machine	344.75
Total	$22,520.00	Total	$20,805.65

In estimating these figures, the committee made allowance for dues which may be in default at the end of the year and for the balance, using last year's receipts as a basis, has kept $200 or $300 below 1923. It is felt, therefore, that they are the minimum rather than the maximum estimates.

It will be noted that there are two new items included in the budget, viz., addressograph machine and motion picture machine. The Secretary stated that our old addressograph had completely worn out and asked the committee to consider including this item in their budget. He further stated that the Board of Direction had considered the purchase of a motion picture machine in order that we might continue the practice started last Fall of showing motion pictures before each of our regular monthly meeetings.

After discussion, it was moved and carried that the committee recommend to the Board of Direction that a new addressograph machine be purchased and included in the budget and, further, that if, in the opinion of the Board, the showing of motion pictures at our regular monthly meetings tended to increase the interest in the meetings and in the Society, they also purchase the motion picture machine and include this item in the budget.

The committee also wish to call the attention of the Board to the present condition of the advertising and the importance of making a special effort to keep it at this level, as it has been largely due to this increase that we have been able to make the financial showing we did this year. The committee further recommended that taking the advertising secured into consideration, the salary of the Secretary be increased to $3,900 per year.

Mr. Crabtree suggested that the Board consider the Finance Committee's report, taking up each individual item as listed.

The purchase of an addressograph machine was first discussed, and it was moved and carried that the House Committee be authorized to purchase the machine for the amount stated.

The question of the motion picture machine was next taken up, and it was moved and carried that the House Committee be authorized to purchase the machine at the amount mentioned in the report.

After a further general discussion, it was moved and carried that the budget for expenditures and receipts as presented by the Committee be accepted and that thanks be extended to the committee for the very thorough manner in which they had gone into the financial matters of the Society.

The Secretary retired from the room while the election of Secretary took place, and Mr. K. F. Treschow was re-elected as Secretary at a salary of $3,900 per year.

It was further moved and carried that the salary of F. O. Shrum be increased $10 per month.

It was suggested that the House Committee arrange to post the names of the officers of the Society and the various committees in the Society Rooms and, after discussion, it was moved and carried that the committee be authorized to see that the names were posted and changed from year to year.

The Secretary presented a letter from Mr. H. M. Kanarr, a member of the Society, in reference to a bill which he wished presented to the State Legislature. After discussion it was moved and carried that this matter be referred to the Civic Affairs Committee.

The Secretary presented a letter from Mr. Billin, Secretary of the Engineers' Club of Philadelphia, enclosing copy of Senate Joint Resolution No. 56, authorizing the President to extend invitations to other nations and to the several states of the United States to participate in a World's Congress of Engineers, to be held in Philadelphia in 1926, asking that this Society endorse this resolution and so notify the proper United States Senators and Representatives.

It was moved and carried that the Secretary be instructed to write the Senate Committee on Foreign Relations endorsing this resolution and urging its early adoption.

The meeting adjourned at 5:55 P. M.

K. F. TRESCHOW, *Secretary.*

STEEL WORKS SECTION

The annual meeting of the Steel Works Section of the Engineers' Society of Western Pennsylvania was held in the Hawaiian Room, William Penn Hotel, Tuesday, January 29, at 8:15 P. M., Chairman G. M. Goodspeed presiding, 73 members and visitors being present.

The minutes of the last meeting, held September 18, were read and approved.

The annual report of the Section was read by the Secretary.

The report of the Nominating Committee was read by the Secretary as follows:

To Officers and Members Steel Works Section:

DEAR SIRS—Your Nominating Committee appointed to nominate officers for the Section for the ensuing year report as follows:

Grant D. Bradshaw.....Chairman
L. C. Edgar.....Vice Chairman
A. C. Fieldner
T. J. McLaughlin
Jesse J. Shuman
Barton R. Shover
Klaus Sollie
.....Directors

Respectfully submitted,

W. C. BUELL, JR., Chairman,
W. B. SKINKLE,
J. S. FULTON,
Nominating Committee.

On motion, the nominations were closed and the Secretary instructed to cast a unanimous ballot for the officers named, and they were thereby declared elected.

No further business coming before the meeting, it was adjourned, and the regular bi-monthly meeting called to order by the retired Chairman in the absence of the new Chairman.

The paper of the evening was presented by Mr. W. B. Chancellor, Department Superintendent, Ellwood Works, National Tube Company, Ellwood City, Pa., on "Manufacture and Use of Seamless Tubing."

The ensuing discussion was participated in by: G. E. Flanagan, Mech. Engr., Heyl & Patterson, Inc.; C. P. Fuller, Sales Engr., Harris Pump & Supply Co.; G. M. Goodspeed, Metallurgist, National Tube Co.; E. O. Mueller, Sales Engr., Sterling Equipment & Supply Co.; O. L. Pringle, Chf. Met. Engr., Pittsburgh Crucible Steel Co.; R. F. Simmons, Pittsburgh Steel Co., Monessen, Pa.; and the author.

On motion, duly seconded and carried, a vote of thanks was extended to Mr. Chancellor for his very interesting paper.

The meeting adjourned at 10 P. M.

K. F. TRESCHOW, *Secretary.*

REGULAR MONTHLY MEETING

The 419th regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Hawaiian Room, William Penn Hotel, Tuesday, February 12, at 8:10 P. M., President Frederic Crabtree presiding, 173 members and visitors being present.

The minutes of the last regular meeting, held December 11, were read and approved.

The Board of Direction reported the election of five applicants to the grade of Member, two to the grade of Associate Member and one to the grade of Junior. Twenty-three applications were received for membership, two reinstatements, 23 resignations received and four deaths reported.

There being no further business before the Society, the paper of the evening was presented on "Pittsburgh Transportation, Parking and Flood Conditions Solved," by Mr. E. K. Morse, Consulting Engineer, Pittsburgh, Pa.

The ensuing discussion was participated in by: Richard Hirsch, Mech. Engr., H. K. Porter Co.; A. H. Burchfield, V. P., Jos. Horne Co.; Fred C. Schatz, Asst. Mgr., Jos. Horne Co.; Thomas M. Rees, V. P. & Gen. Mgr., James Rees & Sons Co.; Winters Haydock, Chf. Engr., Citizens' Committee on City Plan of Pittsburgh; J. P. Leaf, City Engr. & Cons. Engr., Rochester, Pa.; and the author.

On motion the meeting adjourned at 10:30 P. M.

K. F. Treschow, *Secretary.*

MINING SECTION

The annual meeting of the Mining Section of the Engineers' Society of Western Pennsylvania was held in the Hawaiian Room, William Penn Hotel, February 26, at 8 P. M., Chairman H. N. Eavenson presiding, 46 members and visitors being present.

The minutes of the last annual meeting, held January 30, 1923, were read and approved. The annual report of the Chairman was read.

The report of the Nominating Committee was read by the Secretary as follows:

Officers and Members Mining Section,
Engineers' Society of Western Pennsylvania:

Dear Sirs—Your Nominating Committee have appointed the following nominees for the several officers of the Section for the ensuing year:

F. A. McDonald ..... Chairman
R. W. McCasland ..... Vice Chairman
N. G. Alford
J. O. Durkee
M. D. Gibson
N. F. Hopkins
H. R. Miller
} ..... Directors

Respectfully submitted,

H. S. Harrop,
W. A. Weldin,
W. E. Fohl,
Nominating Committee.

On motion, the nominations were closed, and the Secretary was instructed to cast a unanimous ballot in favor of the officers named, and they were, therefore, declared elected.

There being no further business, the meeting adjourned, and the regular bi-monthly meeting called to order by Mr. Eavenson.

No further business coming before the Section, the paper of the evening, on "The Engineer and Housing Problems," was presented by Mr. L. A. Brandt, Project Engineeer, Commerce Housing Corporation, Pittsburgh, Pa.

The ensuing discussion was participated in by: Richard Hirsch, Mech. Engr., H. K. Porter Company; J. M. Rice, Consulting Engr., Pittsburgh, Pa.; E. W. Pittman, Gen. Mgr., Penn Bridge Co., Beaver Falls, Pa.; Winters Haydock, Chf. Engr., Citizens' Committee of City Plan of Pittsburgh; F. M. Van DeVenter, Power Dept., National Tube Co.; B. A. Ludgate, Asst. Engr., P. & L. E. R. R. Co.; W. C. Iffarth, Chf. Engr., Harbison-Walker Refractories Co.; H. Briggs, Technical Engr., Duquesne Light Co.; Thomas Fitzgerald, Gen. Mgr., Pittsburgh Railways Co.; J. D. Underwood, Engineers' Club of Baltimore; F. A. Stevens, Draftsman, H. H. Robertson Co.; N. F. Hopkins, Harrop & Hopkins; G. W. Quentin, Sales Engr., Duquesne Light Co.; and the author.

On motion, the meeting adjourned at 10 P. M.

K. F. Treschow, *Secretary.*

MECHANICAL SECTION

The annual meeting of the Mechanical Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, February 5, at 8:15 P. M., Mr. W. C. Buell, Jr., acting as Chairman in the absence of the Chairman, 69 members and visitors being present.

The minutes of the last annual meeting were read and approved.

The annual report of the Section was read by the Secretary.

The report of the Nominating Committee was read by Mr. Carpenter, Chairman, as follows:

To Members and Officers, Mechanical Section:

Dear Sirs—Your Nominating Committee appointed to nominate officers for the ensuing year for the Mechanical Section give below the following:

W. C. Buell, Jr ..... Chairman
F. M. Van Deventer ..... Vice Chairman
Charles H. Clark
E. J. Deckman
J. S. Fulton
K. W. Gass
R. E. Polk
..... Directors

Respectfully submitted,

C. A. Carpenter, Chairman,
Lewis Vincent,
L. F. Kuhman,
Nominating Committee.

On motion, the nominations were closed, and the Secretary instructed to cast a unanimous ballot in favor of the officers named, and they were, therefore, declared elected.

There being no further business, the meeting adjourned, and the regular bi-monthly meeting was called to order.

The paper of the evening, on "A New Thought in Fuel Engineering," was presented by Henry O. Loebell, V. P. & Gen. Mgr., Combustion Utilities Corp., New York City, N. Y.

The ensuing discussion was participated in by: F. C. Binnall, Const. Engr., Standard Sanitary Mfg. Co.; A. E. Blake, Pgh. Repr., U. G. I. Contracting Co.; W. C. Buell, Jr., Chapman-Stein, Mt. Vernon, O.; J. C. Hobbs, Mgr., Allegheny County Steam Heating Co.; Strickland Kneass, Jr., Steam Engr., Youngstown Sheet & Tube Co.; E. O. Mueller, Sales Engr., Sterling Equipment & Supply Co.; Lewis Vincent. Cons. & Contr. Engr., Pittsburgh.

On motion, duly seconded and passed, a vote of thanks was extended to Mr. Loebell for his very excellent paper.

The meeting adjourned at 10 P. M.

K. F. Treschow, *Secretary.*

BOARD OF DIRECTION

The regular monthly meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the William Penn Hotel, Tuesday, March 18th, at 4:40 P. M., President Crabtree presiding, Messrs. Spellmire, Hobbs, Khuen, James, Knowles, Goodspeed, Weldin, Braden, Buell, McDonald, Harrop and the Secretary being present.

The Minutes of the last meeting held February 12th were approved without reading.

Applications for membership from the following gentlemen, having been published to the Society in accordance with the action of the Board, were elected to membership.

MEMBERS

Barry, Thomas J.
Binnall, Frederick Clifford
Erichson, Wm. B.
Freeman, P. J.
Jones, David Guy
Jordan, Edward Henry
Magill, F. R.
Zimmerman, R. E.
Holmes, Hugh B.

ASSOCIATE MEMBERS

Daniel, T. L.
McKinley, Arch
Van der Kloet, Mark
Wilson, Joseph Charles, Jr.
Spain, Batt L.

The following gentlemen were elected to membership in response to a special invitation from the Board of Direction.

Julian, Burdick
Casey, John F.
Cook, C. S.
Clyde, W. G.
Down, S. G.
Duncan, J. McA.
Firth, L. Gerald
Gadsby, G. M.
Lee, Elisha
Lynch, Clay F.
Lynn, A. M.
Treschow, K. F.

Applications for membership were received from the following gentlemen and their names ordered published to the Society. Assignment to the verious grades of membership is as follows:

MEMBERS

Anderson, Charles Armstrong, Jr.
DeFries, Walter
Dilley, James Max
Donaldson, Robert Robb, Jr.
Ellis, Albert Ralph
Faville, Frederic Alden
Little, Wm. Ross
Nace, Robert R.
Roman, Joseph S.
Scott, Warren Randolph
Sherff, Harry Havlin
Winkleman, Edward J.

ASSOCIATE MEMBERS

Barry, Louis Thomas
Chandler, Jermain
Fixel, William J.
Lawlor, Richard C.
Walker, Harry M.
Somers, John C.

ASSOCIATE

Charles, Howard B.
Boyd, Marcus

JUNIORS

Taylor, Norman C. Totten, John McCleave
Wilcoxsen, Leslie Swales

REINSTATEMENTS

Patterson, F. W. Uptegraff, R. E.

Letters of resignation were received from the following and after discussion, they were ordered accepted.

Robson, D. Brown Rogers, C. B.

The report of the Secretary showing the financial condition of the Society at the close of business February 28th, having been audited by the Finance Committee, was approved.

Mr. Khuen, Chairman of the Civic Affairs Committee, reported that a meeting of the committee had been held on Monday, March 17th, to take up matters referred to them by the Board of Direction and beg to report as follows:

It is recommended that this Society appoint representatives on the various committees of the American Engineering Standards Committee as requested in their letter of December 10th.

In regard to the bill submitted by Mr. H. M. Kanarr, a member of this Society, having to do with the recording of deeds and the laying out of lots, the committee feels that there is considerable merit in this bill but that the two items should be placed in separate bills. They believe, however, that the Practising Engineers are better informed as to the advantages of the bill and are more vitally interested in its passage and therefore recommend that the bill be referred to the Practicing Engineers Section of this Society for their consideration. It was moved and carried that the report of the committee be approved and that the President be authorized to appoint representatives on the committees of the American Engineering Standards Committee and that the above-mentioned bill be referred to the Practicing Section for their consideration, with the request that they report back to the Board of Direction with recommendations.

Mr. Hobbs, Chairman of the Entertainment Committee, reported that arrangements were being made for another theatre party together with several inspection trips, details of which will be announced later.

Mr. Spellmire, Chairman of the Membership Committee, reported that one meeting had been held during the past month to assign applications received since the last meeting of the Board of Direction.

The Secretary read a letter from Mr. Charles E. Billin, Secretary of the Engineers Club of Philadelphia, asking that this Society appoint a representative to serve on the proposed Engineering Council of Pennsylvania. The organization of this council was proposed at a recent gathering in Philadelphia and is to be composed of one representative from each of the local Societies in the State of Pennsylvania in order that they might co-operate on matters of general interest to the Engineers of the State. It was moved and carried that inasmuch as this concerns all the Engineers of Pittsburgh, a representative should be appointed by the Governing Council of the Associated Engineering Societies of Pittsburgh. The matter was therefore referred to them for their action.

The Secretary presented a letter from the Federated American Engineering Societies asking us to appoint a representative on an Advisory Council composed of the Federated American Engineering Societies and other organizations arranged at the conference held in Washington on Jan-

uary 9th, to promote interest in the formation of a Division of Public Works. It was moved and carried that the President be authorized to appoint such a representative.

Mr. Crabtree brought up the subject of the recent proposed lease to Henry Ford of the Muscle Shoals property, stating that several of our members had expressed the opinion that they felt this Society should go on record as protesting against granting a ninety-nine year lease. It was moved and carried that in view of lack of definite information this matter be referred to the Civic Affairs Committee with the request that they secure all possible information and report back to the Board of Direction at as early a date as possible with recommendations.

The Secretary presented a letter from the United National Association of Post Office Clerks in which this Society is asked to endorse the efforts of the Post Office employees to secure a readjustment of their salary classification. After discussion, it was moved and carried that this matter be referred to the Civic Affairs Committee with power to act.

Mr. Buell reported at a meeting of the Special Committee, appointed by the President in accordance with instructions from the Board, had held several meetings. This committee was to consider the advisability of the appointment of a Combustion Standards Committee in accordance with the recommendation made to the Board of Direction. After careful consideration and communicating with several National Organizations it is recommended that this committee be appointed. It was moved and carried that the recommendation of the committee be approved and the President authorized to appoint a Combustion Standards Committee.

The President stated that he had been invited to attend a conference in the office of Mr. Dravo, Chief of the Ordinance Department of this district, at which Mr. Graves, Chairman of the Pittsburgh Section of the A. S. M. E., and several army officers were present. This conference was called to discuss the possibility of a meeting, at which the Assistant Secretary of War, Dwight F. Davis, would speak on industrial mobilization. Mr. Crabtree stated that he had informed Mr. Dravo that the Engineers' Society had an open date on April 15th and we would be very glad to have Mr. Davis speak to the Engineers of Pittsburgh on this date under the auspices of the Engineers' Society of Western Pennsylvania and the Pittsburgh Section of the A. S. M. E. Mr. Crabtree stated that he would like an expression from the members of the Board as to the advisability of having such a meeting. It was moved and carried that the action of the President be endorsed and that this meeting be held under the auspices of the Associated Engineering Societies of Pittsburgh.

The meeting adjourned at 5:55 P. M.

K. F. Treschow, *Secretary.*

JOINT MEETING

Civil Section—Engineers' Society of Western Pennsylvania, Pittsburgh Section—American Institute of Mining and Metallurgical Engineers, and Coal Mining Institute of America.

The regular bi-monthly meeting of the Civil Section of the Engineers' Society of Western Pennsylvania was held in conjunction with the Pittsburgh Section of the American Institute of Mining and Metallurgical Engineers, and the Coal Mining Institute of America, in the Blue Room, William Penn Hotel, Tuesday, March 4th at 8:00 P. M., Chairman, E. V. Braden presiding, 89 members and visitors being present.

The Minutes of the last meeting held November 13, 1923, were read and approved.

No further business coming before the Section, the paper of the evening on "Engineering and Safety Problems of the Coal Mining Industry of Great Britain" was presented by Mr. Henry Walker, C. B. E. and Deputy Chief Inspector of Mines of Great Britain, London, England; and R. V. Wheeler, D. S. C. and Director of Mines Department, Experimental Station, Eskmeals, Sheffield, England.

A general discussion followed the paper.

The meeting adjourned at 10:15 P. M.

K. F. Treschow, *Secretary.*

REGULAR MONTHLY MEETING

The 420th regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, March 18th at 8:00 P. M., President Frederic Crabtree presiding, 52 members and visitors being present.

The Minutes of the last regular meeting held February 12th were read and approved.

The Board of Direction reported the election of 18 applicants to the grade of member, three to the grade of Associate Member and two to the grade of Junior. 14 applications were received for membership, one reinstatement, four resignations received and one death reported.

There being no further business before the Society, the paper of the evening was presented on "Fuel and Power Situation for the Home," by Samuel S. Wyer, Associate in Mineral Technology, Smithsonian Institution, Washington, D. C.

A general discussion followed the paper.

The meeting adjourned at 10:30 P. M.

K. F. Treschow, *Secretary.*

STEEL WORKS SECTION

The regular bi-monthly meeting of the Steel Works Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, March 25th, at 8:00 P. M., Chairman G. D. Bradshaw presiding, 54 members and visitors being present.

The Minutes of the last meeting held September 18th were read and approved.

There being no further business before the Section, the paper of the evening on "Refractories for Metallurgical Furnaces" was presented by Mr. G. A. Bole, Supt., Ceramics Experiment Station, U. S. Bureau of Mines, Columbus, Ohio.

The ensuing discussion was participated in by Frank M. Van Deventer, National Tube Company, Pittsburgh; R. M. Howe, Kier Fire Brick Company, Pittsburgh; G. W. Hughes, Pittsburgh Steel Company, Monessen; and the author.

On motion duly seconded and carried, a vote of thanks was extended to Mr. Bole for his very interesting paper.

The meeting adjourned at 10:15 P. M.

K. F. Treschow, *Secretary.*

BOARD OF DIRECTION

The regular monthly meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the Society Room, Tuesday afternoon, April 15th, at 4:30 P. M., President Crabtree presiding, Messrs. Spellmire, Stucki, Hobbs, Leland, Goodspeed, Weldin, James, Buell, Braden, McDonald and the Secretary being present.

The Minutes of the last meeting held March 18th, were approved without reading.

Applications for membership from the following gentlemen, having been puublished to the Society in accordance with the action of the Board, were elected to membership.

MEMBERS

Anderson, Charles Armstrong, Jr.
De Fries, Walter
Dilley, James Max
Donaldson, Robert Robb, Jr.
Ellis, Albert Ralph
Faville, Frederick Alden
Little, Wm. Rose
Nace, Robert R.
Roman, Joseph S.
Scott, Warren Randolph
Sheaff, Harry Havlin
Trees, J. C.
Winkleman, Edward J.

ASSOCIATE MEMBERS

Barry, Louis Thomas
Chandler, Jermain
Fixel, William J.
Lawlor, Richard C.
Walker, Harry M.
Somers, John C.

ASSOCIATE

Charles, Howard B.
Boyd, Marcus

JUNIORS

Taylor, Norman C.
Wilcoxson, Leslie Swales
Totten, John McCleave

Applications for membership were received from the following gentlemen and their names ordered published to the Society. Assignment to the various grades of membership is as follows:

MEMBERS

Jenkins, Raymond Rhys
Moyer, W. I.
Schauer, Franklin Frederick
Taylor, David Edwin

ASSOCIATE MEMBERS

French, G. O.
Mattingley, Geo. B.

ASSOCIATE

Dym, Emanuel
Foster, William Barclay
Rabberman, A. Leslie
Worthington, Harvey R.

JUNIORS

Jenks, S. M.
Karch, Herbert Stiffler
Schuck, Norman Louis

The report of the Secretary showing the financial condition of the Society at the close of business March 31st, having been audited by the Finance Committee, was approved.

Mr. Khuen, Chairman of the Civic Affairs Committee, reported that in accordance with action taken at the last meeting of the Board at which time you referred to this committee the matter of the leasing of the Muscle Shoals Property to Henry Ford by the United States Government on the 99-year lease, we beg to report that this committee met on Friday, April 4th, and after considering the subject thoroughly do not feel that they had, or are in a position to secure enough information to permit them to make recommendations to you.

They, therefore, respectfully refer this subject back to the Board of Direction without recommendations.

After discussion it was moved and carried that the report of the committee be received and tabled.

The House Committee reported an attendance in the Club Room for the month of April of 323.

The fourth annual Chess Tournament was started on March 24th, and will continue until May 5th. The Bridge Tournament was completed on April 9th.

The attendance at our noon day lunches is still growing, the highest number to date being 127.

Mr. Spellmire, Chairman of the Membership Committee reported that one meeting of the committee had been held to assign applications received since the last meeting of the Board.

The meeting adjourned at 5:50 P. M.

K. F. Treschow,
Secretary.

BOARD OF DIRECTION

The regular monthly meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the William Penn Hotel, Tuesday, May 20th at 4:30 P. M., President Frederic Crabtree presiding, Messrs. Fohl, Hobbs, Khuen, James, Braden and the Secretary being present.

The Minutes of the last regular meeting held April 15th, were approved without reading.

Applications for membership from the following gentlemen, having been published to the Society in accordance with the action of the Board, were elected to membership.

MEMBERS

Jenkins, Raymond Rhys
Moyer, W. Irwin
Schaner, Franklin Frederick
Taylor, David Edwin

ASSOCIATE MEMBERS

French, G. O.
Mattingley, George B.

ASSOCIATES

Dym, Emanuel
Foster, Wm. Barclay
Rabberman, A. Leslie
Worthington, Harvey R.

JUNIORS

Karch, Herbert Stiffler
Jenks, Stephen M.
Schuck, Norman Louis

Applications for membership were received from the following gentlemen and their names ordered published to the Society. Assignment to the various grades of membership is as follows:

MEMBERS

Agthe, Fred T
Connor, Edward Harrison
Meharg, Lawrence
Morison, George Smith
Olin, Otto
Powelson, Frank W.
Taylorson, Ewart S.
Thomas, Edgar A.

ASSOCIATE MEMBERS

Bouvy, Christian Houdyn
Hansen, W. J.
McRoberts, Wm. Hamilton
Mitchell, T. J.
Specht, Carl A.

ASSOCIATES

Hurn, David Charles

JUNIORS

Strickler, J. Harold
Carmichael, David Charles

Application for transfer was received from Mr. Batt L. Spain and after discussion, he was transferred to the grade of Member.

Letters of resignation were received from the following gentlemen and after discussion they were ordered accepted:

R. A. McDonald
W. R. Neely
B. M. Ogden
M. D. Scott
E. A. Wilcox

The Secretary reported the death of Mr. Albert Ladd Colby who joined the Society January 1904 and died April 30, 1924.

The report of the Secretary showing the financial condition of the Society at the close of business April 30th, having been audited by the Finance Committee, was approved.

The Secretary presented reports on the two inspection trips and ladies' night entertainment held since the last meeting of the Board of Direction as follows:

Hazel Atlas Glass Co., Washington, May 3rd. Receipts $101.00; Expenditures $153.88; Deficit $52.88. Attendance 155.

Weirton Steel Co., Weirton, W. Va., April 25th. Attendance 148. Receipts $500; Expenditures $498.74; Net gain $1.26.

Ladies' Night Entertainment, April 24th. Attendance 92. Receipts $130.08; Expenditures $268.08; Deficit $124.08.

The Secretary read a letter from Mr. Herbert Hoover in regard to our assisting in securing the cooperation of the manufacturers and public in general in this district in buying their coal during the months of May, June and July in order to avoid a car shortage in the Fall when the traffic is heavier due to the moving of the crops and winter goods.

It was moved and carried that the Secretary write Mr. Hoover to the effect that we will be glad to call this matter to the attention of our membership.

The meeting adjourned at 5:15 P. M.

K. F. Treschow, *Secretary.*

CIVIL SECTION

The regular bi-monthly meeting of the Civil Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, May 6th at 8:30 P. M., Chairman E. V. Braden presiding, 49 members and visitors being present.

The Minutes of the last meeting held March 4th, were read and approved.

No further business coming before the Section, the paper of the evening on "The Erection of Steel Bridges," was presented by Mr. N. H. Orr, Assistant Engineer, American Bridge Co., Pittsburgh, Pa.

A general discussion followed the presentation of the paper.

On motion, duly seconded and carried, a vote of thanks was extended to Mr. Orr for his very interesting paper.

The meeting adjourned at 9:40 P. M.

K. F. Treschow, *Secretary.*

APRIL REGULAR MONTHLY MEETING

The 421st regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in conjunction with the local sections of the following Societies on Tuesday, April 15th at 8:00 P. M. in the Ball Room of the William Penn Hotel, President Frederic Crabtree presiding, 1600 members and visitors being present:

American Society of Mechanical Engineers.
American Institute of Electrical Engineers.
American Inst. Mining & Metallurgical Engineers.
American Chemical Society.
American Society for Steel Treating.
American Electro-Chemical Society.
Illuminating Engineering Society.

American Society of Civil Engineers.
Society of American Military Engineers.
99th Division Organized Reserves, U. S. A.
American Association of Engineers.

The Minutes of the last regular meeting and of the Board of Direction were approved without reading.

President Crabtree introduced Mr. A. W. Thompson, President of the Philadelphia Co., who formally introduced the speaker of the evening, Hon. Dwight L. Davis, Assistant Secretary of War. Col. Davis spoke on "Industrial Mobilization."

The address was followed by some very interesting motion pictures secured from the War Department.

The meetng adjourned at 10:30 P. M.

K. F. Treschow, *Secretary.*

MAY REGULAR MONTHLY MEETING

The 422nd regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Hawaiian Room, William Penn Hotel, Tuesday, May 20th, at 8:08 P. M., Past President, Henry D. James presiding, 147 members and visitors being present.

The Minutes of the last regular meeting held April 15th, were read and approved.

The Board of Direction reported the election of four applicants to the grade of Member, two to the grade of Associate Member, four to the grade of Associate and three to the grade of Junior. There was one reinstatement, the transfer to higher grade of one member and five resignations accepted. One death was reported.

No further busniess coming before the Society, the paper of the evening was presented by Mr. George A. Richardson, Bethlehem Steel Company, and Bethlehem Steel Corp., Ltd., on "Manufacture and Production of Steel."

Motion pictures were shown illustrating the paper.

A general discussion followed the presentation of the paper.

A vote of thanks was extended to the speaker for his very interesting paper.

On motion the meeting adjourned at 10:20 P. M.

K. F. Treschow, *Secretary.*

BOARD OF DIRECTION

The regular monthly meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the William Penn Hotel, Tuesday, June 10th, at 4:40 P. M., President Frederic Crabtree presiding, Messrs. Spellmire, Ellis, Leland, Weldin, Goodspeed, Braden, McDonald and the Secretary being present.

The minutes of the last regular meeting, held May 20th, were approved without reading.

Applications for membership from the following gentlemen, having been published to the Society pursuant to the action of the Board, were elected to membership:

MEMBERS

Agthe, Fred T.
Connor, Edward Harrison
Meharg, Lawrence
Morison, George Smith
Olin, Otto
Powelson, Frank W.
Taylerson, Ewart S.
Thomas, Edgar A.

ASSOCIATE MEMBERS

Bouvy, Christiaan Houdyn
Hansen, N. J.
McRoberts, Wm. Hamilton
Specht, Carl A.
Mitchell, T. J.

ASSOCIATE

Hurn, John Sydney

JUNIORS

Carmichael, David Charles
Strickler, J. Harold

Applications for membership were received from the following gentlemen and their names ordered published to the Society. Assignment to the various grades of membership is as follows:

MEMBERS

Graham, John A.
Ladenburg, Carl E.
Melcher, John P.
Rugg, W. S.
Skinner, M. E.

ASSOCIATE MEMBERS

Armstrong, Gordon Lee
Finnicum, J. L.

ASSOCIATE

Felker, Ray B.

JUNIORS

Hoban, C. O.
Magnani, Charles

Applications for reinstatement were received from the following gentlemen and, after discussion, the Secretary was requested to advise them of their reinstatement to membership:

Davis, H. P.
Voelker, Aloys A.

Applications for transfer were received from the following members and, after discussion, the Secretary was requested to advise them of their transfer to full membership:

Daniel, Thomas Lester
Mitchell, Thomas J.
Voelker, Aloys A.

COMMITTEE REPORTS

The Secretary reported, on behalf of the Entertainment Committee, a most successful trip last Saturday through the new Atlantic Exchange of the Bell Telephone Company, the attendance being 110. He further reported that the committee had completed plans for a golf tournament to be held at the Shannopin Country Club on June 20th, notice of which is being mailed today. This event will close the activities of the committee for the summer months. However, they expect to hold three or four inspection trips early in the fall.

Mr. Spellmire, Chairman of the Membership Committee, stated that one meeting had been held to consider applications received since the last meeting, as well as act on any other business coming before the committee. The revised list of executives for engraved invitations was presented and, after discussion, were approved and the Secretary requested to send them engraved invitations.

On motion, the meeting adjourned at 5:15 P. M.

K. F. Treschow, *Secretary.*

MECHANICAL SECTION

The regular bi-monthly meeting of the Mechanical Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, June 3rd, at 8:13 P. M., Vice Chairman F. M. VanDeventer presiding in the absence of the Chairman.

The minutes of the last regular meeting, held February 5th, were read and approved.

No further business coming before the Section, the paper of the evening, on "Classification of Pyrometers and Their Application," was presented by Mr. R. W. Newcomb, General Manager, Charles Engelhard, Inc., New York City.

The ensuing discussion was participated in by: W. M. Austin, Engr., Westinghouse Elec. & Mfg. Co.; F. S. Bloom, South Side Works, Jones & Laughlin Steel Corp.; E. H. Coxe, Sub-Station Dept., Duquesne Light Co.; Phillip Dressler, American Dressler Tunnel Kilns, Cleveland, O.; W. J. Merten, Met. Engr., Westinghouse Elec. & Mfg. Co.; E. B. Plapp, Mech. Engr., U. S. Aluminum Co.; L. J. Reed, Test Engr., Carnegie Steel Co., Duquesne, Pa.; F. M. VanDeventer, Power Dept., National Tube Co.; and the author.

On motion, duly seconded and carried, a vote of thanks was extended to the author for his very interesting paper.

The meeting adjourned at 10:22 P. M.

K. F. Treschow, *Secretary.*

REGULAR MONTHLY MEETING

The 423rd regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, June 10th, at 8:16 P. M., President Frederic Crabtree presiding, 73 members and visitors being present.

The minutes of the last meeting, held May 20th, were read and approved.

The Board of Direction reported the election of eight applicants to the grade of Member, five to the grade of Associate Member, one to the grade of Associate and two to the grade of Junior, and the receipt of 13 applications for membership. Also one reinstatement and two applications for transfer to higher grade were reported.

The President announced that Mr. L. C. Frohrieb was the winner of the chess tournament and Mr. Henry Pennywitt was the winner of the bridge tournament, and cups were presented to both.

The President also announced the coming golf tournament, which is to be held June 20th.

Due to illness, the paper on "Refractories" to be presented by Mr. J. M. McKinley, V. P. of the Crescent Refractories Co., had to be postponed and, in its stead, a series of educational films produced by the U. S. Bureau of Mines and the Standard Oil Co. were shown on "The Story of Gasoline," followed by two films of the Link-Belt Co. on their revolving dumpers for grain and coal.

On motion, duly seconded and approved, a vote of thanks was extended to the U. S. Bureau of Mines and also to Mr. Webster, of the Link-Belt Co., for these very interesting films.

The meeting adjourned at 10:15 P. M.

K. F. Treschow, *Secretary.*

MINING SECTION

The regular bi-monthly meeting of the Mining Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, June 24th, at 8 P. M., Chairman F. A. McDonald presiding, 20 members and visitors being present.

The minutes of the last meeting, held February 26th, were read and approved.

No further business coming before the Section, the paper of the evening, on "Concentration in Coal Mining," was presented by Mr. E. B. Moore, Manager, Pittsburgh Office, Coal Service Corporation, Pittsburgh, Pa.

The ensuing discussion was participated in by: Graham Bright, Consulting Engr., Howard N. Eavenson & Associates; Louis P. Blum, Blum, Weldin & Co.; T. G. Fear, Gen. Supt., Inland Collieries Co., Indianola, Pa.; R. H. Schaller, Asst. Supt., By-Products Coke Plant, Jones & Laughlin Steel Corp.; F. A. McDonald, Gen. Supt. & Chf. Engr., National Mining Co., Morgan, Allegheny Co, Pa.; F. W. Powelson, Civil Engr., Pressed Steel Car Co.; and the author.

A vote of thanks was extended to Mr. Moore for his very interesting paper.

On motion, the meeting adjourned at 10:10 P. M.

K. F. Treschow, *Secretary.*

BOARD OF DIRECTION

The regular monthly meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the Wm. Penn Hotel, Tuesday, Sept. 23rd at 4:40 P. M., President Frederic Crabtree presiding, Messrs: Spellmire, Fohl, James, Knowles, Ellis, Khuen, Leland, Braden, McDonald, Weldin, Goodspeed, and the Secretary being present.

The Minutes of the last meeting held June 10th were approved without reading.

Applications for membership from the following gentlemen, having been published to the Society, pursuant to the action of the Board, were elected to membership.

MEMBERS

Graham, John A.
Ladenburg, Carl E.
Melcher, John P.
Rugg, W. S.
Skinner, M. E.

ASSOCIATE MEMBERS

Armstrong, Gordon Lee
Finnicum, J. L.

ASSOCIATE

Felker, Ray B.

JUNIORS

Hoban, C. O.
Magnani, Charles

INVITATIONS

Baker, Thomas S.
Brown, Charles M.
Campbell, R. D.
Fownes, Wm. C., Jr.
Harter, Isaac
Matheson, George, Jr.

Applications for membership were received from the following gentlemen and their names ordered published to the Society. Assignment to the various grades of membership is as follows:

MEMBERS

Butler, Thomas Emmet
Headings, Wm Wade
Bloom, Frederick Sturate
Flanagan, Edward W.
Culbertson, Albert Lewis
Elliot, Robert T.
Everson, George Marshall
Hess, Charles Edward
Hicks, John R.
Kroto, G.
Leinbach Warren C.
Miller, Durando
Morgenstern, W. C.
Morris, Alfred A.
Moeller, N.
Reed, Van A., Jr.
Rieger, W. H.
Scott, Maxwell Williams
Stevenson, W. W.
Townrow, Frederick Wazney
Uhlinger, Roy H.
Work, Clayton Wight

ASSOCIATE MEMBERS

Bailey, Charles Chester
Bisler, Walter Edward
Miner, Philip H.
Stevenson, Barton

ASSOCIATE

Riegel, Clarence L.

JUNIORS

Anatole, Julian Joseph
Breed, Charles Warren
Brown, Samuel Byrne
Ellman, Fred
Upham, Howard B.
Senn, Charles Moyer

Application for reinstatement were received from the following gentlemen and after discussion the Secretary was requested to advise them of their reinstatement to membership.

Moore, Lee C. Johnson, Geo. R.

Applications for transfer were received from the following gentlemen and after discussion, the Secretary was requested to advise them of their transfer to the following grades.

Cooley, H. M., Junior Pettay, G. T., Assoc. Member
Fohl, C. T., Junior Clifford, T. C., Member

The death of the following members were reported:

J. W. Kelly, joined Jan. 1885, died April 28, 1924; Walter Kennedy, joined Dec. 1902, died July 6, 1924; Harry Lauder, joined May 1885, died ....., 1924; H. T. Randolph, joined July 1912, died Aug. 23, 1924; Thos. Roberts, joined Jan. 1880, died Feb. 25, 1924.

The reports of the Secretary showing the condition of business June 30th, July 31st, and Aug. 31st, having been audited by the Finance Committee were approved.

COMMITTEE REPORTS

The Secretary presented the resignation of Mr. Hobbs as Chairman of the Entertainment Committee, due to the fact that he has left Pittsburgh and did not feel he would be able to give the work the attention it required. After discussion it was moved and carried that Mr. Hobbs' resignation be accepted with regret.

It was moved and carried that Mr. T. C. Clifford be made Chairman of this committee for the remainder of this year.

Mr. Fohl, Chairman of the Finance Committee, reported that in accordance with the statement enclosed with the announcement of the Board meeting, our finances were in good shape and that indications were that we would finish this year in better financial condition than for some years past. He further reported that in connection with our moving the following expenditures had been made upon the approval of the House Committee and the President of the Society.

Brass rail installed in office	$137.50
Rugs, cleaned and bound	37.20
Moving	25.00
Cuspidors	15.00
Total	$214.70

The Committee has also secured bids for coat racks from several firms to be installed in the office for use of the members at noon and other times and have selected the best type, estimated cost of which is $40.00 each and recommended that five of these racks be purchased at a total cost of $200.00.

After discussion it was moved and carried that the thanks of the Board be extended to the Finance and House Committee for the manner in which arrangements for the new club room had been completed with the hotel and the way in which the expenses incident to making the change had been kept down and further that they be authorized to purchase five coat racks at price quoted above.

Mr. Leland, Chairman of the House Committee, reported an evening attendance for the months of June, July and August of 758. He further reported that the House Warming on the evenings of Sept. 17th, 18th and 19th had been most successful, quite a number of the members taking advantage of the opportunity to bring their families in and see the rooms. Special attention was called to the fact that the attendance for the first three weeks

in September was 467, quite an increase over the previous attendance prior to the opening of our new room.

Detailed statement was also given the Board as to the change in arrangements whereby we secured the Hawaiian Room instead of the quarters of the Princeton Club as discussed at the last meeting.

Mr. Spellmire, Chairman of the Membership Committee, stated that a meeting of the Committee had been held to act upon the applications received since the last meeting, as well as any resignations, reinstatements or transfer.

The Secretary read the following letter from Mr. J. C. Hobbs:

Mr. K. F. Treschow, Secy.,

Engineers' Society of Western Penna.

Dear Sir:

I find it very difficult indeed to announce that my pleasant activities with the Engineers' Society must be very greatly curtailed on account of my leaving the city to accept a position with the Diamond Alkali Co. at Painesville, O.

I have very greatly enjoyed my work with the Society, and am undoubtedly indebted to it to a degree more than I can express. My term as a Director is very nearly at an end, but in case you desire to substitute some one immediately who will be available, I am submitting my resignation from that position. I want it clearly understood that I am not resigning from the Society, because my future work will be a continuation of a combination of executive and engineering duties.

It will be necessary to appoint a successor at once to take up the Entertainment Committee work because of the many activities which must be arranged immediately.

I have greatly appreciated the consideration and courtesies shown by my associates in the Society, and particularly the members of the Board of Direction and the efficient Secretary with whom I had the pleasure of working. My best wishes are extended to all for a Happy and Prosperous Future.

Most cordially yours,

(Signed) J. C. Hobbs.

After discussion it was moved and carried that Mr. Hobbs' resignation be accepted as Director, with regret.

The matter of election of a director to replace Mr. Hobbs was then brought before the meeting and after discussion, it was moved and carried that Mr. T. C. Clifford be elected to fill the vacancy caused by Mr. Hobbs' resignation.

Mr. Fohl, Chairman of the Medal Awards Committee presented the following report of the Medal Awards Committee on papers for the year 1923:

To the Board of Direction,

Engineers' Society of Western Penna.

A meeting of the Medal Awards Committee was held in the Society Rooms, at which it was decided to award the silver medal to Messrs. J. C. Hobbs and L. W. Heller for their paper on Pulverized Fuel for Large Boilers.

Respectfully submitted,

W. E. Fohl, *Chairman*,

G. D. Bradshaw,

R. Khuen, Jr.

After discussion it was moved and carried that the silver medal be awarded to Mr. Hobbs and Mr. Heller and the Secretary be instructed to have the two medals made.

In connection with this report, Mr. Fohl called attention to the fact that under the rules governing medal awards, only members of the Society are eligible for award. He stated that the Committee had discussed this phase of the rules and the opinion had been expressed that these rules should be changed in order that non-members might also receive medals, inasmuch as very often these speakers came from other cities and have gone to a great deal of expense and trouble in order to present papers. It was felt, therefore, that for exceptionally valuable papers they should receive recognition whether members of the Society or not.

After a general discussion, it was moved and carried that this matter be referred to the President and Secretary with the suggestion that they look up the history of the rules and if possible find out what the motive had been in confining the awards to members of the Society, report to be made at the next meeting of the Board.

The Secretary brought up the matter of again publishing in our List of Members the Constitution and By Laws. These have not been published for the past two years, due to an effort to economize in printing and inasmuch as our finances are in better shape, this could be cared for this year if desired.

After discussion it was moved and carried that the Constitution and By Laws be printed in the 1924 year book and that the Secretary be instructed to have additional copies run so as to supply new members next year in order that they may be omitted in the 1925 year book if thought desirable.

The Secretary presented a letter from Mr. L. W. Wallace, Executive Secretary of the American Engineering Council suggesting that this Council had under consideration the possibility of calling a meeting of the different executive Secretaries of local engineering societies of the country for the purpose of comparing notes and discussing common problems. Mr. Wallace asked for an expression from this Society as to whether or not they would recommend that their Secretary participate in such a conference.

After a general discussion, it was moved and carried that the Secretary be instructed to inform Mr. Wallace that this Society would approve of its Secretary attending an informal gathering such as mentioned in his letter.

The meeting adjourned at 5:45 P. M.

K. F. Treschow, *Secretary.*

REGULAR MONTHLY MEETING

The 424th regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, Sept. 23rd at 8:08 P. M., President Frederic Crabtree presiding, 91 members and visitors being present.

The minutes of the last meeting were read and approved.

The Board of Direction reported the election of five to the grade of Member, two to the grade of Associate Member, one to the grade of Associate, two to the grade of Junior and the receipt of six acceptances to engraved invitations. Thirty-three applications were received for membership; two reinstatements; transfer to higher grade of four members, five deaths reported and seven resignations accepted.

President Crabtree appointed Mr. J. M. Graves as Chairman of the Nominating Committee, with Mr. F. I. Ellis, Mr. N. F. Hopkins, Mr. C. M. Reppert and Mr. Graham Bright as the balance of the committee to nominate officers for the ensuing year.

There being no further business, the paper of the evening was presented by Mr. C. M. Ripley, Engineer, General Electric Co., Schenectady, N. Y. on "Labor and Power Here and Abroad".

Motion pictures were also shown on Revelations by X-Ray.

On motion a vote of thanks was extended to Mr. Ripley for his very interesting paper and pictures.

On motion the meeting adjourned at 10:25 P. M.

K. F. Treschow, *Secretary.*

SPECAL MEETING

A special meeting of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Monday, September 8th at 8:20 P. M., President Frederic Crabtree presiding, 196 members and visitors being present.

The reading of the minutes was dispensed with, this being a special meeting.

The Secretary made an announcement in regard to the Convention of the Association of Iron and Steel Electrical Engineers being held next week at Duquesne Gardens, to which the members of the Society were specially invited.

An address was made by Lieut. John A. Macready, Engineering Division, Air Service, U. S. Army, McCook Field, Dayton, Ohio on the "Engineering Aspects of Flying".

Owing to the lateness of the hour, there was no discussion.

A vote of thanks was extended to Lieut. Macready for his very interesting lecture.

On motion the meeting adjourned at 10:05 P. M.

K. F. Treschow, *Secretary.*

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BOARD OF DIRECTION

The regular monthly meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the William Penn Hotel, Tuesday, Oct. 21st at 4:35 P. M., President Frederic Crabtree presiding, Messrs. Spellmire, Ellis, Clifford, Goodspeed, Weldin, Khuen, Leland, Braden, McDonald, Bradshaw, Knowles and the Secretary being present.

The minutes of the last meeting held Sept. 23rd, were approved without reading.

Applications for membership from the following gentlemen, having been published to the Society, pursuant to the action of the Board, were elected to membership.

MEMBERS

Butler, Thomas Emmet
Culbertson, Albert Lewis
Elliott, Robert T.
Everson, George Marshall
Flanagan, Edward W.
Headings, Wm. Wade
Hess, Charles Edward
Kroto, George
Hicks, John R.
Leinbach, Warren C.
Miller, Durando
Morgenstern, W. C.
Morris, Alfred A.
Moeller, N.
Reed, Van A., Jr.
Rieger, W. H.
Scott, Maxwell Williams
Stevenson, W. W.
Townrow, Frederick Wazney
Uhlinger, Roy H.
Work, Clayton Wight

ASSOCIATE MEMBERS

Bailey, Charles Chester
Bisler, Walter Edward
Miner, Philip H.
Stevenson, Barton

ASSOCIATES

Riegel, Clarence L.

JUNIORS

Anatole, Julian
Bloom, Frederick Sturate
Breed, Charles Warren, Jr.
Brown, Samuel Byrne
Ellman, Fred
Upham, Howard B.
Senn, Charles Moyer

Applications for membership were received from the following gentlemen and their names ordered published to the Society. Assignment to the various grades of membership is as follows:

MEMBERS

Atkinson, George H.
Comstock, Glen Moore
Gunther, Felix A.
McMichaels, W. A.
Pearce, Leonard George
Riegler, L. J.
Thomas, George W.
Williams, Samuel B.

In accordance with the By Laws, I. S. Wishoski, a student junior was transferred to the grade of Junior.

The Secretary reported the death of Mr. J. A. Ruiloba who joined the Society, May, 1904 and died Sept. 30, 1924.

The report of the Secretary showing the condition of business Sept. 30th, having been audited by the Finance Committee, was approved.

The Secretary reported on behalf of the Entertainment Committee stating that in accordance with action taken at the last meeting of the Board, Mr. T. C. Clifford had consented to act as Chairman and one meeting of the Committee had been held during the past month to arrange for several functions to be held this Fall. Plans are also being carried on in connection with the Annual Banquet.

Mr. Leland, Chairman of the House Committee, reported an evening attendance for the month of September of 563, which number includes the three evenings of the House Warming.

Mr. Spellmire, Chairman of the Membership Committee, stated that one meeting had been held during the month to act upon any applications received since the last meeting and make recommendation as to their grade of membership.

Mr. Spellmire, further stated that a letter of invitation was to be sent to members of the four National Societies located in this district inviting them to become members under a ruling of the Board remitting entrance fees and without filling out the usual application form.

The meeting adjourned at 5:40 P. M.

K. F. Treschow, *Secretary.*

MECHANICAL SECTION

The regular bi-monthly meeting of the Mechanical Section of the Engineers' Section of Western Pennsylvania was held jointly with the Pittsburgh Section of the American Society of Mechanical Engineers on Monday evening, Oct. 6th at 8:08 P. M., Chairman L. C. Frohrieb of the A. S. M. E. presiding, 86 members and visitors being present.

The minutes of the last meeting held June 3rd, were read and approved.

No further business coming before the Section the paper of the evening on "Recent Developments in High Pressures and Superheat" was read by Mr. B. N. Broido, Chief Engineer, Superheater Company, New York, N. Y.

The ensuing discussion was participated in by: L. C. Frohrieb, Pres., Federal Engineer Co., Pittsburgh; G. G. Bell, Mgr., Power Development, West Penn Power Co., Pittsburgh; L. W. Heller, Gen. Supt., Power Stations, Duquesne Light Co., Pittsburgh; and the Author.

On motion duly seconded and carried, a vote of thanks was extended to Mr. Broido for his very interesting paper.

The meeting adjourned at 10:00 P. M.

K. F. Treschow, *Secretary.*

REGULAR MONTHLY MEETING

The 425th regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, October 23rd at 8:00 P. M., President Frederic Crabtree presiding, 62 members and visitors being present.

The minutes of the last meeting held 16th were read and approved.

The Board of Direction reported the election of 22 applicants to the grade of Member, four to the grade of Associate Member, one to the grade of Associate and six to the grade of Junior. Also the receipt of seven ap-

plications for membership, one resignation, one death reported, one member transferred to higher grade and one member dropped.

No further business coming before the Society, the paper of the evening on "Power and Industry" was presented by Mr. T. O. Kennedy, Vice President and General Manager, Ohio Public Service Corporation, Cleveland, O.

On motion the meeting adjourned at 10:30 P. M.

K. F. Treschow, *Secretary.*

STEEL WORKS SECTION

The regular bi-monthly meeting of the Steel Works Section of the Engineers' Society of Western Pennsylvania was held in the William Penn Hotel, Tuesday, October 28th, at 8:10 P. M., Mr. W. Trinks presiding in the absence of the chairman, 76 members and visitors being present.

The Minutes of the last meeting held March 25th were read and approved.

No further business coming before the Section, the paper of the evening on "Pickling of Sheet Steel" was presented by Mr. Ewart S. Taylerson, Engineer of Tests, American Sheet & Tin Plate Co., Pittsburgh, Pa.

The ensuing discussion was participated in by: W. Trinks, Professor, Carnegie Institute of Technology; F. F. Ross, South Side Works, Jones & Laughlin Steel Corp.; E. R. Daniel, American Sheet & Tin Plate Co.; W. M. Parkin, Pres., Hoffman Process Co.; B. H. Pease, Sharon Steel Hoop Co.; W. M. Austin, Engr., Westinghouse Elec. & Mfg. Co.; J. H. Snyder Sales Engr., Mesta Machine Co.; H. H. Downes, Dist. Mgr., American Blower Co.; K. F. Stahl, Consulting Chemist, Pittsburgh; L. W. Haag, Chief Engr., Apollo Steel Co., Apollo, Pa.; H. C. Schroyer, Apollo Steel Co., Apollo, Pa.; Barton R. Shover, Consulting Engineer, Pittsburgh; P. F. Herman, Consulting Engineer, Pittsburgh; and the Author.

On motion a vote of thanks was extended to Mr. Taylerson for his very interesting paper.

The meeting adjourned at 10:35 P. M.

K. F. Treschow, *Secretary.*

BOARD OF DIRECTION

The regular monthly meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the Society Rooms, William Penn Hotel, Tuesday, November 18, at 4:40 P. M., President Frederic Crabtree presiding, Messrs. Spellmire, Fohl, Leland, Khuen, Clifford, Weldin, McDonald, James and the Secretary being present.

The minutes of the last regular meeting were approved without reading.

Applications for membership from the following gentlemen, having been published to the Society, pursuant to the action of the Board, were elected to membership:

MEMBERS

Atkinson, George H.
Comstock, Glen Moore
Gunther, Felix A.
McMichaels, W. A.
Pearce, Leonard George
Riegler, L. J.
Thomas, George W.
Williams, Samuel B.

Applications for membership were received from the following gentlemen and their names ordered published to the Society. Assignment to the various grades of membership is as follows:

MEMBERS

Chalker, Albert R.
McNaughton, Adam (Quartet)
Pharo, Harry Alexander
Williams, Harold E.

ASSOCIATE MEMBERS

Renton, Walter C (Quartet)
Tilton, Robertson (Quartet)

ASSOCIATE

Wiester, Blanchard C (Quartet)

JUNIOR

Ryman, Charles F.

NATIONAL SOCIETY ACCEPTANCES

MEMBERS

Barr, J. Carroll
Colgan, Charles J.
Connell, H. R.
Crumbaugh, J. J.
Davis, Jefferson
Deike, George H.
Dunn, H. Earl
Endsley, Louis E.
Eichleay, Harry O.
Farnham, Thad L.
Finn, Matthew J.
Johnson, F. E.
Jones, Jonathan
Karpov, A. V.
Lambert, M. B.
Lesher, C. E.
Lower, N. M.
Simpson, George H.
Smith, Harold W.
White, Harold E.

ASSOCIATE MEMBERS

Behney, C. C.
Blohm, A. H.
Cameron, E. H.
Frank, Harry H.
Handloser, B. F.
Mirick, A. S.

ASSOCIATES

Adair, W. R.
Broadberry, Waldie
DeCamp, Harry H.
Fetherling, H. G.
Freund, C. J.
Jungman, L. Leverin
Kramer, T. M.
Oparin, Basil J.
Seidle, N. R.
Shupe, H. P.
Grimes, Royce L.
Stimpson, Clarence A.
Wolfe, E. L.

JUNIORS

Heink, Herman Charles
Forrest, Clifford L.
Harman, William W.
Blanton, H. J.
Blenker, Walter J.

STUDENT JUNIORS

Carl, Wellington C.
Muckenhaupt, Carl F.
Mueller, Mark G.

Letters of resignation were received from the following and, after discussion, they were ordered accepted:

C. G. Webb N. C. Wilson

The Secretary reported the death of the following members:

S. S. Baker.....Joined January, 1922; died October 23, 1924

W. M. Judd.....Joined November, 1901; died November 13, 1924

The report of the Secretary showing the financial condition of the Society at the close of business October 31, having been approved by the Finance Committee, was approved.

Mr. Clifford, Chairman of the Entertainment Committee, reported an attendance of 83 at the Ladies' Night party. This was an unusually small attendance, due probably to the inclemency of the weather. A statement of expense sand receipts was presented.

Report was also presented on the Election Night party. Mr. Clifford stated that between three and four hundred were in the rooms on Election Night and everyone seemed to enjoy themselves. The expenses for this evening were $122.88.

Mr. Fohl, Chairman of the Finance Committee, reported that he had nothing of special importance to call to the attention of the Board, except that our finances continued in good shape and we were keeping within our estimated budget.

Mr. Leland, Chairman of the House Committee, reported an evening attendance of 368 for the month of October.

Mr. Spellmire, Chairman of the Membership Committee, reported that one meeting had been held to assign applications received and transact any other business coming before the Committee. Mr. Spellmire also stated that 1746 invitations had been mailed to the National Societies, and up to the present time 47 acceptances had been received.

It was moved and carried that the report of the Membership Committee be accepted and that the thanks of the Board be extended to the Committee and the Secretary for the excellent work done in connection with the letters mailed to members of these societies.

In accordance with Article 5, Section 5, of the By-Laws, the following report of the Nominating Committee was presented:

November 18, 1924.

To the Board of Direction,
Engineers' Society of Western Pennsylvania

Dear Sirs:

A report of the Nominating Committee was held Monday, November 17, to nominate officers for the ensuing year, and wish to present the following report:

For President.....Walter B. Spellmire
For Vice-President.....George T. Ladd
For Treasurer.....A. Stucki
For Directors..... { T. C. Clifford / W. L. Affelder

In accordance with the policy of the Nominating Committee in the past few years, the Committee selected the nominee for a Vice-President from among the list of Directors whose term had expired in the past, rather than selecting from the two Directors whose terms expire in January.

Respectfully submitted,

J. M. Graves, *Chairman*,
N. F. Hopkins,
C. M. Reppert,
F. I. Ellis,
Graham Bright,
Nominating Committee.

After discussion, it was moved and carried that the report of the Nominating Committee be accepted and the Secretary instructed to publish the report in accordance with the By-Laws.

The Secretary read a letter from Mr. Knowles, who was unable to attend the meeting, stating that the Board of Directors of the American Society of Civil Engineers was to hold its regular meeting in Pittsburgh on or about December 1, and suggested that the Engineers' Society act as host and make the visit of these engineers as attractive and comfortable as possible. He also stated that he thought it advisable the Board might entertain the visitors at dinner in the evening.

After a general discussion, during which it was brought out that the local section was making plans for entertaining the Board at dinner, it was moved and carried that the Secretary be authorized to make whatever

arrangements that seemed advisable for a dinner without interfering with the local section officers and that a letter be sent to the Secretary of the A. S. C. E. extending an invitation to them to make use of our facilities and services during their stay in Pittsburgh.

The Secretary presented a letter from Mr. Wallace, Secretary of the Federated American Engineering Societies, stating that, in accordance with their recent correspondence, arrangements have been made for a conference to take place in Washington on January 15. The Secretary pointed out that this might be rather an inconvenient time for him to leave the city, due to the Annual Meeting and the Annual Dinner, and suggested that the Board permit him to decline the invitation to attend if it was found that affairs in the office were not in such shape that he could get away.

It was moved and carried that the Secretary's suggestion be approved and the matter be left entirely to his judgment as to whether or not he attend the conference.

The meeting adjourned at 5:45 P. M.

K. F. Treschow, *Secretary.*

CIVIL SECTION

The regular bi-monthly meeting of the Civil Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Wednesday, November 5, at 8:10 P. M., Chairman E. V. Braden presiding, 129 members and visitors being present.

The minutes of the last meeting, held May 6, were read and approved.

No further business coming before the Section, the paper of the evening was presented on "Some Notes on Foundations," by Mr. Charles R. Gow, Consulting Engineer, Boston, Mass.

Written discussion was presented by: Major E. L. Daley, Major, U. S. Army, U. S. District Engineer; Morris Knowles, Pres. & Chf. Engr., Morris Knowles, Inc.

The ensuing discussion was participated in by: C. McDonough, Asst. Dist. Mgr., The Foundation Company; Winters Haydock, Chf. Engr., Citizens' Committee on City Plan of Pittsburgh; C. N. Haggart, Struct. Engr., Pittsburgh; F. M. McCullough, Professor Civil Engineering, Carnegie Inst. of Technology; T. B. Sturgess, Pres., Pennsylvania Drilling Co.; P. J. Freeman, Chf. Engr., Tests & Specifications, Allegheny County; J. S. Martin, Struct. Engr., Duquesne Light Co.; and the author.

On motion, duly seconded and carried, a vote of thanks was extended to Mr. Gow for his very interesting and instructive paper.

On motion, the meeting adjourned at 10:35 P. M.

K. F. Treschow, *Secretary.*

REGULAR MONTHLY MEETING

The 426th regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, November 18, at 8:15 P. M., President Frederic Crabtree presiding, 63 members and visitors being present.

The minutes of the last meeting, held October 23, were read and approved.

The Board of Direction reported the election of eight applicants to the grade of member and the receipt of 53 applications for membership, 47 of which were applications received from the national societies accepting our invitation to join the Society. Also two resignations were accepted and two deaths reported.

No further business coming before the Society, the paper of the evening, on "Forestry," was presented by Major R. Y. Stuart, Department of Forests and Waters, Commonwealth of Pennsylvania, Harrisburg, Pa.

A general discussion followed the presentation of the paper.

On motion, the meeting adjourned at 10:30 P. M.

K. F. Treschow, *Secretary.*

MINING SECTION

The regular bi-monthly meeting of the Mining Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday evening, November 25, at 8:13 o'clock, 66 members and visitors being present.

The minutes of the last meeting, held June 24, were read and approved.

No further business coming before the Section, the paper of the evening, on "Rock Dusting Bituminous Coal Mines," was presented by Mr. T. G. Fear, General Manager, Inland Collieries Company, Indianola, Pa.

The ensuing discussion was participated in by: W. L. Affelder, Asst. to Pres., Hillman Coal & Coke Co. and Subsidiaries; Graham Bright, Cons. Engr., Howard N. Eavenson and Associates; A. R. Chambers, Gen. Agent, Michigan Limestone & Chemical Co.; J. M. Crystle, Supt., Vestaburg Coal Co.; A. C. Fieldner, Supt., Pittsburgh Experiment Station, U. S. Bureau of Mines; R. A. McDonald, Gen. Supt. & Chf. Engr., National Mining Co.; N. F. Hopkins, Civil & Mining Engr., Harrop & Hopkins; George Nelms, Sales Mgr., Mines Safety Appliances Co.; and the author.

On motion, duly seconded, a vote of thanks was extended to Mr. Fear for his very interesting paper.

The meeting adjourned at 9:20 P. M.

K. F. Treschow, *Secretary.*

BOARD OF DIRECTION

The regular monthly meeting of the Board of Direction of the Engineers' Society of Western Pennsylvania was held in the William Penn Hotel, Tuesday, December 9th, at 4:40 P. M., President Frederic Crabtree presiding. Messrs. Fohl, Clifford, Weldin, Goodspeed, Braden, McDonald, Harrop, James and the Secretray being present.

The Minutes of the last regular meeting were approved without reading.

Applications for membership from the following gentlemen, having been published to the Society pursuant to the action of the Board, were elected to membership.

MEMBERS

Chalker, Albert R.
McNaughton, Adam
Pharo, Harry Alexander
Williams, Harold E.

ASSOCIATE MEMBERS

Renton, Walter C.
Tilton, Robertson

ASSOCIATE

Wiester, Blanchard C.

JUNIOR

Ryman, Charles F.

NATIONAL SOCIETY ACCEPTANCES

MEMBERS

Barr, J. Carroll (ASCE)
Colgan, Chas. J. (ASCE)
Connell, H. R. (AIEE)
Crumbaugh, J. J. (AIM&ME)
Davis, Jefferson (AIM&ME)
Deike, George H. (AIM&ME and ASME)
Dunn, H. Earl (ACS and AIM&ME)
Eichleay, Harry O. (ASME)
Endsley, Louis E. (ASME)
Farnham, Thad L. (ASME)
Finn, Mathew J. (ASME)
Johnson, F. E. (ASME)
Jones, Jonathan (ASCE)
Karpov, A. V. (AIEE)
Lambert, M. B. (AIEE)
Lesher, C. E. (AIM&ME)
Lower, N. M. (ASME)
Simpson, George H. (ASCE)
Smith, Harold W. (AIEE)
White, Harold E. (AIEE and ASME)

ASSOCIATE MEMBERS

Cameron, E. H. (ASME)
Blohm, A. H. (ASME)
Frank, Harry H. (ASCE)
Mirick, A. S. (ASCE)
Behney, C. C. (ASME)
Handloser, B. F. (ASME)

ASSOCIATES

Adair, W. R. (AIEE)
Broadberry, Waldie (AIEE)
DeCamp, Harry H. (AIEE)
Fetherling, H. G. (AIEE)
Freund, C. J. (AIEE)
Grimes, Royce L. (AIEE)
Jungman, L. Leverin (AIEE)
Kramer, T. M. (AIEE)
Oparin, Basil J. (AIEE)
Seidle, N. R. (ASME)
Shupe, H. P. (AIEE)
Stimpson, Clarence A. (AIEE)
Wolfe, E. L. (AIEE)

JUNIORS

Blanton, H. J, (ASME)
Blenko, Walter J. (ASME)
Forrest, Clifford L. (ASME)
Harman, William W. (ASME)
Heink, Herman C. (ASME)

STUDENT JUNIORS

Carl, Wellington C. (AIEE)
Mueller, Mark G. (AIEE)
Muckenhaupt Carl F. (AIEE)

Applications for membership from the following gentlemen, having been ordered published to the Society were assigned to the following grades.

MEMBERS

Buchanan, Edward Roberts
Daryman, Thomas A.

ASSOCIATE MEMBER

Brosky, Alphonse F.

ASSOCIATE

Clark, William F.

JUNIOR

McCreery, Maxwell

ACCEPTANCES NATIONAL SOCIETY MEMBERS

MEMBERS

Cadman, A. M.
Carr, U. U.
Foss, Feodore F.
Hook, C. Howard
Lavine, Saul
Matthews, Charles H.
Mueller, H. N.
Robinson, J. French
Rust, W. F.
Smoot, C. H.
Weise, Paul H.
Willard, J. O.

ASSOCIATE MEMBERS

Cappeau, J. P.
Demorest, Geo. M.
Phelps, S. B.

ASSOCIATE

Elshoff, R. H.

JUNIORS

Cotter, George L.
Lindeman, Reginald G.
Mann, N. T.
Wood, Iver C.

Application for transfer was received from Mr. Hennen J. Blanton and after discussion, he was transferred to the grade of Member.

The Secretary reported the death of Mr. R. G. Sommerfeld who joined Sept. 1903 and died Nov. 21, 1924 and Mr. Lucien Scaife, who joined March 1883 and died Dec. 3, 1924.

It was moved and carried that the President and Secretary be asked to secure a memoir of Mr. Scaife for publications in the Proceedings.

The report of the Secretary showing the financial condition of the Society at the close of business, Nov. 30th, having been audited by the Finance Committee, was approved.

Mr. Clifford, Chairman of the Entertainment Committee reported that the Committee was working on the Annual Banquet and had tentatively secured two speakers. They do not wish to make any announcements at this time but hope to have a list completed by the latter part of December.

Mr. Leland, Chairman of the House Committee, reported an evening attendance of 651 for the month of November, 300 of this number being the election night party.

In accordance with Article 5, Section 5 of the By Laws, it was moved and carried that the nominations as published to the Society be finally approved, and that letter ballots be mailed to the entire membership in accordance with the By Laws.

On motion the meeting adjourned at 5:00 P. M.

K. F. TRESCHOW, *Secretary*

MECHANICAL SECTION

The regular by-monthly meeting of the Mechanical Section of the Engineers' Society of Western Pennsylvania was held jointly with the Pittsburgh Section of the American Society of Mechanical Engineers, Tuesday evening, December 2nd, at 8:20 P. M., Mr. L. C. Frohrieb, Chairman of the A. S. M. E. presiding in the absence of Mr. Buell, Chairman of the Mechanical Section, 52 members and visitors being present.

The Minutes of the last meeting held Oct. 6th, were read and approved.

No further business coming before the Meeting, the paper of the evening on Industrial Heating was presented by Mr. Thornton Lewis, Vice President, York Heating & Ventilating Corporation, Philadelphia, Pa.

The ensuing discussion was participated in by: W. M. Austin, Engr., Westinghouse Elec. & Mfg. Co.; A. E. Blake, Pgh. Repr., U. G. I. Contracting Co. of Philadelphia; E. C. Brandt, Works Mgr., Homewood Works, Westinghouse Elec. & Mfg. Co.; J. A. Graham, Supt., Buildings and Grounds, Shady Side Academy; A. T. Ruttencutter, Industrial Heating Sales, Westinghouse Elec. & Mfg. Co.; H. P. Smith, Chief, Statistical Division, Duquesne Light Co.; D. C. Williams, Mech. Engr., National Tube Company; P. A. Young, Mech. Engr., Duquesne Light Company; and the author.

On motion duly seconded and carried, a vote of thanks was extended to the author for his very interesting and instructive paper.

The meeting adjourned at 10:20 P. M.

K. F. TRESCHOW, *Secretary*

REGULAR MONTHLY MEETING

The 427th regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Tuesday, December 9th at 8:20 P. M., Vice President W. E. Fohl presiding, 63 members and visitors being present.

The minutes of the last regular meeting held Nov. 18th, were read and approved.

The Board of Direction reported the election of 24 applicants to the grade of Member, 7 to the grade of Associate Member, 15 to the grade of Associate, 6 to the grade of Junior and 3 to the grade of Student Junior and the receipt of 25 applications for membership, transfer of one member to higher grade and two deaths reported.

No further business coming before the Society, the paper of the evening on "Elimination of Industrial Waste with Side Lights on Mexico" was presented by Harrington Emerson, President, The Emerson Engineers, New York City, N. Y.

A general discussion followed the presentation of the paper.

On motion the meeting adjourned at 10:35 P. M.

K. F. TRESCHOW, *Secretary*

STEEL WORKS SECTION

The regular bi-monthly meeting of the Steel Works Section of the Engineers' Society of Western Pennsylvania was held in the Blue Room, William Penn Hotel, Thursday evening, Dec. 18th, at 8:20 P. M., Mr. L. C. Frohrieb presiding, 73 members and visitors being present.

The Minutes of the last meeting held Oct. 28th were read and approved.

No further business coming before the Section, the paper of the evening on "How to Obtain Higher Thermal Results in Boiler Room and the Relation Between Efficiency and Economic Values" was presented by Mr. J. G. Worker, Assistant to President, American Engineering Co., Philadelphia, Pa.

The ensuing discussion was participated in by: H. W. Brooks, Fuel Engr., U. S. Bureau of Mines; L. C. Frohrieb, Pres., Federal Engineering Co.; J. A. Graham, Supt., Buildings and Grounds, Shady Side Academy; F. K. Howell, Supt., Compressing Stations, Duquesne Light Co.; John A. Hunter, Steam & Sanitary Engr., American Sheet & Tin Plate Co.; Sidney J. McAuliffe, Cons. Engr., Gilbert, McAuliffe Pty. Ltd., Melbourne, Australia; E. B. Plapp, Mech. Engr., U. S. Aluminum Company; L. J. Reed, Test Engr, Carnegie Steel Co.; W. H. Ritts, Chf. Engr., Spang Chalfant Co.; Lewis Vincent, Consulting Engineer; Wm. Whigham, Jr., Eff. Engr., Clairton By-Products Coke Co., Carnegie Steel Co.; and the author.

On motion, duly seconded and carried, a vote of thanks was extended to Mr. Worker for his very interesting paper.

The meeting adjourned at 10:30 P. M.

K. F. Treschow, *Secretary*

NECROLOGY

Amsbary, D. H.

Baker, S. S.

Black, S. W.

Campbell, J. W.

Chalfant, J. G.

Chess, H. B. Jr.

Colby, A. L.

Dilworth, E. C.

Donohue, E. P.

Follet Louis

Hammond, J. R.

Hildner, L. F. W.

Hoerr, A. L.

Hoopes, William

Jones, P. N.

Judd, W. M.

Kelly, J. W.

Kennedy, Walter

Lauder, George

Randolph, H. T.

Roberts, Thomas

Ruiloba, J. A.

Schmidt, Walter

Seaman, J. S.

Snyder, W. E.

Sommerfeld, R. G.

Summers, E. W.

Taylor, E. B.

Tener, G. E.

Wadsworth, D. T.

Warwick, W. H.

Wilson, Howard

James Graham Chalfant

Born August 6, 1869, in Wilkins Township, Allegheny County, Pennsylvania.

Died August 26, 1922, in Wilkinsburg, Pa.

Joined the Society in June, 1904.

He was the oldest son of Henry R. and Evaline R. (Graham) Chalfant, and came of pioneer ancestry.

After attendance at the public schools of Wilkinsburg, he attended Wooster University through the sophomore year.

His first employment in engineering work was as rodman and transitman with the Pittsburgh & Western Railway (now B. & O. R. R.) from 1891 to 1893. During the next three years he was armor plate marker for the Carnegie Steel Company; rodman on the construction of the buildings of the Westinghouse Electric & Manufacturing Company at East Pittsburgh, and again transitman with the Pittsburgh & Western Railway.

Upon the organization of the Road Department of Allegheny County, early in 1897, he was chosen one of the three assistant engineers and had charge of road construction in the northern section of the county. In 1900 he was employed for a few months as transitman on the Pennsylvania Lines West of Pittsburgh, and then entered the service of the city of Pittsburgh as assistant engineer and later as principal assistant engineer in the Bureau of Surveys. In March, 1907, he was chosen county engineer of Allegheny County, which position he held until his death.

While with the railroads he was engaged in a number of development projects, and while in the service of the City of Pittsburgh his work was characterized by painstaking records, which were always available to those interested.

During his years of service as county engineer he had charge of the design and erection of the Ohio River Bridge at Sewickley, the Allegheny River Bridge at Hulton, and the Monongahela River Bridge at Monongahela, Pa. He had supervision of the design and erection of the Soldiers and Sailors' Memorial Hall and the City-County Building.

As a result of the order of the Secretary of War requiring that the bridges on the lower Allegheny River be altered and raised, he gave a great deal of study to the problem.

The plans for the Allegheny River bridges at Sixteenth street (now nearly completed) and at Fortieth street, Pittsburgh, were prepared under his direction.

Extensive studies were made for the proposed Ohio River Bridge at McKees Rocks, and plans prepared for the proposed bridge over the Monongahela river at Wilson-Glassport under his supervision.

He is survived by his widow, Mrs. Edla Steele Chalfant; two sons, James G. Jr., and Alexander Steele; his mother; three brothers, Dr. Sidney A. Chalfant, Henry R. Chalfant and Frederick B. Chalfant, and three sisters, Mrs. Mary C. Scudder, Mrs. Martha C. McNary and Evaline M. Chalfant.

Leonard Frederick William Hildner

Born May 6, 1872, in Detroit, Mich.
Died June 2, 1923, in Pittsburgh, Pa.
Joined the Society in April, 1901. Director 1921-23.

Mr. Hildner was the son of the Rev. John G. and Johanna Hildner, and his childhood residence was in Detroit, where his early school training occurred. His college and technical training were received at the University of Michigan, from which he graduated with the degree of B. S. in 1893.

His first employment was as teacher of algebra in Detroit High School in 1894. In the same year he became associated with the Detroit Bridge & Iron Works, where he remained two years.

In 1896 he entered the employ of the Riter-Conley Manufacturing Company as a draftsman at the Preble Avenue Works, North Side, Pittsburgh, Pa. In 1898 he became chief draftsman of this company, at times having responsibility for 100 draftsmen working on all varieties of fabricated steel work, including mill buildings, bridges, elevators, docks, tanks, and steel frame story buildings, and machinery for fabricating and erecting them. He applied to this exacting responsibility high technical ability and a gentle firmness in his relations with superiors and subordinates, which made him not only a

highly valued part of the organization, but also a sincere friend of all with whom he came in contact.

In 1905 he became chief engineer of the Pittsburgh Bridge & Iron Works, then newly organized, and was vice president and director of the company at the time of his death.

Mr. Hildner joined the Engineers' Society of Western Pennsylvania in April, 1901, and took an active interest in its work. In 1921 he was elected a director and continued to serve until his death. He contributed to the PROCEEDINGS of the Society on many occasions, both formal papers and in discussions, and was an authority in his special line of engineering work as well as an efficient officer.

Mr. Hildner was married October 10, 1901, to Rexa M. Laughfitt, of Pittsburgh. He had four children, Helen C., Richard C., Mary R. and David K.

WILLIAM HOOPES

Born July 20, 1867, in Westchester, Pa.
Died January 9, 1924, in Pittsburgh, Pa.
Joined the Society in March, 1913. Director 1915 and 1916.

William Hoopes, chief electrical engineer of the Aluminum Company of America, died in St. Francis' Hospital, Pittsburgh, Pa., at 10 o'clock Wednesday evening, January 9, 1924. His health had been failing for some time, but neither his family nor his friends knew that he was seriously ill until a few days before his death.

Daniel Hoopes, an English Quaker, who joined the Penn colony in Pennsylvania in 1683, a year after the first settlement, was William Hoopes' ancestor. William Hoopes was born in a house near Westchester which had been in the family continuously since it was built by Daniel Hoopes subsequent to the latter's making his home in this country. Mr. Thomas Hoopes, the father of William Hoopes, is now in his ninetieth year and lives in Westchester.

The paternal grandmother of William Hoopes was a Darlington, her brother having been William Darlington, a prominent lawyer and banker in Westchester. His mother was Amanda Russell, the daughter of Thomas Russell, a merchant in Baltimore, with a summer

home in Harford County, Maryland. All four of Mr. Hoopes' grandparents were Quakers.

William Hoopes attended the Friends' School and the State Normal School in Westchester, and later on the Spring Garden Institute in Philadelphia, which is a technical school, where he laid the foundation for his engineering training. While in the Westchester State Normal School he studied physics and chemistry under Prof. C. B. Cochran and became very much interested in scientific subjects at an early age. Prof. Cochran is still living and, since Mr. Hoopes' death, Prof. Cochran has commented on the exceptional ability and enthusiasm which the young man displayed in these studies. As a boy he built telegraph sets, magneto telephones and other electrical apparatus, showing an early tendency toward originality and invention.

Mr. Hoopes spent but one year at Lehigh University, that of the fall of 1885 and until the summer of 1886, inasmuch as the electrical engineering course at Lehigh University at that time comprised but one year. In his class was Parsons, afterwards an engineer of renown, and one of the principal designers of electric generators for the General Electric Company in the nineties. Mr. Parsons lived for many years in London and has since died.

Marr & Doubleday, electrical contractors, was the first firm with which Mr. Hoopes was employed, and the Edison lighting plant for the general supply of St. Paul, Minn., and the Sprague Electric Railway equipment for Los Angeles, Cal., were among the first installations upon which he worked. Afterwards he installed a number of smaller plants in Southern Delaware and Eastern Maryland, and thereafter acted as superintendent of the lighting plants in some of the western suburbs of Philadelphia.

About 1899 Mr. Hoopes came to Pittsburgh and joined the staff of the Westinghouse Electric & Manufacturing Company, and the early part of 1900 he entered the employ of the then Pittsburgh Reduction Company, with which organization he has been continuously since that time, although the corporate name was later changed to the Aluminum Company of America. Mr. Hoopes held the position of chief electrical engineer, and for seven years was head of the research and technical departments of the company.

Mr. Hoopes was a man of remarkable genius. He possessed an unusual faculty of concentration, and his ability to cultivate an idea

to a sound conclusion was such that his advice and guidance in the operations of the Aluminum Company were of the greatest assistance in keeping that industry in the leadership which it has always held in America. Largely through the efforts of Mr. Hoopes aluminum has become established on a par with copper as an electrical conductor for high-voltage transmission. His other accomplishments mark him as one of the leading engineers of the world in his chosen field of metallurgy.

He possessed a personality of rare qualities. His consideration for the opinions and interests of others, his great modesty and his gentleness of character, coupled with his unusual brilliance of mind, endeared him to all of his acquaintances.

He was a member of the American Institute of Electrical Engineers, the Pittsburgh Athletic Association and the Oakmont Country Club, as well as the Engineers' Society of Western Pennsylvania. He took a great interest in the meetings and work of the Engineers' Society and spent much of his free time during the latter part of his life in its rooms.

Mr. Hoopes is survived by his wife (Dorothy Stockton), daughter of the late Rev. William Rodgers Stockton, of Phoenixville, Pa.; a daughter, Mrs. F. Crosman Fitler, of Pittsburgh, and a grandson, F. Crosman Fitler, Jr. Besides Mr. Hoopes' father, Thomas Hoopes, of Westchester, Pa., there is his sister, Miss Emily Hoopes, of Westchester; Charles R. Hoopes and Arthur Hoopes, of Westchester, and Maurice Hoopes, of Glen Falls, N. Y.

Thomas Paschall Roberts

Born April 21, 1843, in Carlisle, Pa.
Died February 25, 1924, in Pittsburgh, Pa.
Joined the Society in January, 1880.
Director 1884-1885 and 1889-1890. President 1891.

Thomas Paschall Roberts, familiarly known as Colonel Roberts, was born in Carlisle, Pa., on April 21, 1843. He was the son of W. Milnor Roberts, a noted civil engineer of canal and early railway days, and a grandson of Chief Justice John Bannister Gibson, of Pennsylvania. He died at his residence, 361 North Craig street, Pittsburgh, on February 25, 1924.

In 1854 he, with his parents, first moved to Pittsburgh. Subsequently, after also residing temporarily in other localities, the family moved back to Carlisle, whence Colonel Roberts returned to Pittsburgh in 1866, making this city his permanent home.

He was educated in public and private schools in the cities where his parents were located temporarily, and thereafter entered Dickinson and State colleges, leaving the latter as an undergraduate in 1863 to join his father in the engineering and construction of the Don Pedro Railroad in Brazil.

Following his return to the States in the fall of 1865 he took charge of surveys in Northwestern Pennsylvania for a projected railroad financed by English capitalists. In 1866 he became principal assistant to his father in charge of the open-channel improvement of the entire Ohio River, which position he retained until 1870, when illness compelled him to relinquish it. From 1870 until 1884 Colonel Roberts was engaged on or in charge of numerous railroad and waterway surveys, including several construction projects, in various sections of the country. Notable among these were the Montana Division of the Northern Pacific Railroad, the Cincinnati & Northern Railroad to Michigan, the West Wisconsin Railroad (now a part of the Chicago & Northwestern Railroad), the Western Maryland Railroad into Pennsylvania, and the Pittsburgh & Atlantic Railroad, a part of the Louisville & Nashville system in Kentucky, and a narrow-gauge railroad from Pittsburgh to Washington, Pa. Also in the early seventies he made a reconnoissance of the upper Missouri River from Fort Benton to the Three Forks, his report and map of which were published by the War Department in 1874. He named some of the Missouri River falls — Black Eagle, Rainbow and others — which names they still retain. He surveyed the upper Monongahela River to Fairmont, W. Va., in 1875, and the Allegheny River from Freeport, Pa., to Olean, N. Y., in 1878-9.

The latter half of his life was devoted almost entirely to waterway improvements and matters relating to navigation, in which he developed an unusual interest. In 1884 he became chief engineer of the Monongahela Navigation Company, which then owned and operated seven locks and dams on the lower Monongahela River. This position he held until the United States Government purchased the company's plant in 1897. With the transfer of these works Colonel

Roberts again entered the service of the United States Engineer Department, retaining local charge of the Monongahela River improvements during the greater part of their reconstruction period until 1912, thereafter serving as consulting engineer in an advisory capacity in the United States Engineer Office at Pittsburgh until he severed his connection with the service under the Federal Retirement Act on August 20, 1922. While associated with the Government engineer service he was ever an ardent advocate of water transportation and lived to see a remarkable revival in river shipments.

About 1889 he became interested in the proposed building of a canal between Lake Erie and the Ohio River near Pittsburgh, and in 1890 Governor Beaver appointed him chief engineer of the Ship Canal Commission of Pennsylvania to conduct the necessary surveys for determining the feasibility of the scheme. After an intensive study of the existing conditions he was in 1894 made chairman of an engineering committee designated by the Pittsburgh Chamber of Commerce to make a complete survey and prepare a report on the proposed canal as to its practicability. This survey he undertook, and upon its completion submitted a comprehensive outline of the project with reports, maps and models showing its entire feasibility. That eventually the construction of the Lake Erie and Ohio River Canal via Beaver River would be accomplished he seemed to entertain no doubt.

He was one of the organizers of this Society in 1880, and in 1891 served as its President. He also was one of the organizers of the Botanical Society of Western Pennsylvania and of the Pittsburgh Academy of Science and Arts. He was a life manager of the Pittsburgh Exposition Society, and for many years was an active and influential member of the Chamber of Commerce of Pittsburgh, in which he served as director and Vice-President. He also was a member of an informal club designated the Monday Club, which met at intervals to discuss scientific subjects. Although its membership was quite limited, it included such noted scientists as Prof. John A. Brashear, Prof. Keeler, Prof. Fessenden and Prof. Langley.

In the civic affairs of the community Colonel Roberts always took a lively interest, invariably aligning himself on the side of the best interest of the public, as he believed. His natural disposition to strict uprightness and his kindliness and helpfulness to his associates won for him the lasting friendship of many who now mourn his loss.

Perhaps his outstanding endowment was his love for matters scientific. To these he devoted his profoundest study and exerted his best thought. On such subjects he was a prolific, competent and interesting writer and for many years made frequent contributions to the newspapers and magazines. Whenever he conceived of an interesting or valuable idea he immediately imparted it to others. He wrote the memoirs of his grandfather, Chief Justice Gibson, which were published in 1890.

Colonel Roberts' marriage to Miss Juliette Emma Christy, daughter of James M. Christy, attorney-at-law, took place on June 8, 1870, at St. Peter's Episcopal Church, Pittsburgh. Mrs. Roberts died in 1907. Their children are: Eleanor Christy, wife of W. H. Baltzell, chief engineer, Canadian Steel Corporation, Ojibway, Ontario, Canada; Miss Annie Gibson, Pittsburgh; Juliette Paschall, wife of Major General William L. Sibert, U. S. Army, a former member of this Society (Mrs. Sibert died in 1918); Laura Milnor, deceased; Thomas P., Jr., attorney-at-law, Pittsburgh; J. Milnor, civil engineer graduate of the University of Pittsburgh in 1910, Sewickley, Pa.; and Mary Brunot, wife of Major Francis K. Newcomer, U. S. Army, Charleston, S. C.

Joseph Sidney Seaman

Born August 14, 1839, in Harmony, Pa.
Died June 15, 1921, in Pittsburgh, Pa.
Joined the Society in October, 1898.

Joseph Sidney Seaman, prominently connected with the iron and steel district for sixty years, died at his home June 15, 1921.

He was born in Harmony, Butler County, Pa., on August 14, 1839, and at the age of 17 moved to Pittsburgh, beginning his industrial career here as a carpenter. About a year later he decided to enter the iron industry, having been offered a chance to learn roll turning. From that time until his death he was continuously interested in the production of iron and steel.

During the Civil War his skill was in demand for the making of cannons. After a few years as an employee, successively, of the Pittsburgh Foundry Company, Hussey, Wells & Co., and the Black

Diamond Steel Works, he helped to establish a small business which, after various changes in personnel and name, was incorporated in 1885 as the Seaman-Sleeth Company. Thirty-two years later, with a reputation unexcelled by any roll manufacturers in the country, this company changed its name to the Pittsburgh Roll Corporation and Mr. Seaman gave up his active control of its operations, but remained as chairman of the board.

The past twenty years have seen an enormous development of the uses for strip steel, both hot rolled and cold rolled. Mr. Seaman early became interested in the Superior Steel Company and had a considerable part in making it so great a success in that line of steel manufacture. He was also for many years president of the Pennsylvania National Bank and the Pennsylvania Savings Bank.

Besides being for 23 years a member of the Engineers' Society of Western Pennsylvania, Mr. Seaman helped to organize the American Foundry Men's Association, and was at one time its president. Always actively interested in its affairs, he gave the Association $5,000 to encourage research work. His interest in public charities was typified by his service as chairman of the board of the Passavant Hospital.

In all the various lines of activity Mr. Seaman was distinguished by sterling character, sound judgment, breadth of view, deep sympathy and a personality that aroused the love and unfaltering loyalty of his associates, and the sincere respect of all with whom he came in contact.

Mr. Seaman was an honor to the Engineers' Society of Western Pennsylvania, to the city in which he lived, and the industry which he so long served.

William Emery Snyder

Born June 15, 1868, in Allegheny County, Pa.

Died June 24, 1922, in Pittsburgh, Pa.

Joined the Society in 1899.

Director 1913, 1914 and 1915. Vice-President 1916 and 1917. President 1918.

Mr. Snyder was born in Bethel Township, Allegheny County, Pennsylvania, June 15, 1868. He was educated in the public schools, Curry Institute, Duquesne College and Pennsylvania State College, where he graduated in 1896, receiving the degree of mechanical engineer. His technical work started in 1895, after his junior year at State College, during the summer vacation, at the Shoenberger Steel Company, now part of the American Steel & Wire Company. After graduating in 1896, he again associated himself with this company as a draftsman, and later as an assistant in the construction of open-hearth furnaces. After seven months of this experience Mr. Snyder was given the position of steam engineer in the master mechanic's department. This position gave him an opportunity to become familiar with the uneconomical methods used in the production and use of steam. To quote Mr. Snyder: "It was these conditions that originally started me in the steam engineering work, because there seemed to be a crying need of somebody to do something along this particular line at that place. Previous to that everybody thought this was a district of cheap coal and nobody need pay any attention to economy in its use. The inconsistency of such a careless attitude in reference to lavish wastefulness of labor and material going to produce power, while at the same time industrious and intelligent laborers could hardly make enough to feed and house their families, was a condition which certainly should not continue to exist."

The American Steel & Wire Company was founded in 1899, shortly after which he was appointed assistant master mechanic at Shoenberger Works. His work here soon attracted attention and very shortly he began to be called to other works of this company in the Pittsburgh district. As a result of this experience he was appointed steam or power engineer for the Pittsburgh district, in which position he continued until February 12, 1902, at which time he was given the position of mechanical engineer of the company under the vice-president and general superintendent, in which capacity he continued until his death.

This was primarily an operating position, the work being of a widely diversified character, comprehending in a general way the supervision of all varieties of manufacturing equipment using fuel or heat in any way. The American Steel & Wire Company operates over thirty different manufacturing plants, located at various places

between the Atlantic Ocean and the Mississippi River. To provide these works with power to drive them alone requires between 500 and 600 boilers, aggregating over 150,000 H. P.; over 200 large steam engines, gas engines, steam turbines, and such auxiliary installations as electric power stations, pump plants, etc. In addition, there are large numbers of gas producer plants, heating furnaces and other miscellaneous furnaces, consuming in round numbers a million tons of coal more; and also large quantities of natural gas, fuel oil, etc.

The maintenance of such a large quantity of such varied equipment in good practical operating condition, as well as the improvement of efficiencies of the various parts of all this equipment, was a task which continually brought up new and difficult problems of almost every possible variety, and it was to such work as this that he devoted most of his time and energy. In addition he had some special experience which may be of interest.

In the latter part of 1908 there was formed a Steam Engineers or Power Committee in the United States Steel Corporation; Mr. Snyder was secretary of this committee and prepared all of its reports.

In the early part of 1908 he was delegated by the American Steel & Wire Company to investigate the utilization of blast furnace and coke oven gas in Europe. On this trip he visited a large number of manufacturing plants in France, Germany, Austria, Belgium, Holland, England, Wales, Switzerland and Italy. In the summer of 1913 he made another trip to Europe with a party of members of the American Society of Mechanical Engineers.

Mr. Snyder was a member of the Eleventh United Presbyterian Church, of North Side, Pittsburgh; McCandless Lodge No. 390, Free and Accepted Masons; Zerubbabel Chapter No. 162, and Tancred Commandery No. 48, K. T.; the American Society of Mechanical Engineers, the Engineers' Society of Western Pennsylvania, the American Iron and Steel Institute and of several foreign engineering societies.

Mr. Snyder was a man of exceptionally high moral standards and one who always stood ready to help others. He took an active interest in civic affairs and the advancement of his profession. His work in the local and national engineering societies will be much missed.

He was fond of art and music, and used music as a diversion, belonging to a mixed chorus and at times sang in church choirs.

Mr. Snyder was interested in all kinds of outdoor life, his particular hobby being trapshooting. He was also fond of hunting small game and fishing, and camped several summers in the northern part of Ontario, enjoying these sports.

On September 29, 1898, he married Miss Anna B. Freeman, of Crossingville, Pa. Mrs. Snyder and one daughter, Margaret, survive him.

Edward Ballinger Taylor

Born February 6, 1850, in Riverton, N. J.

Died November 8, 1922.

Charter member 1880. President of the Society 1886. Director 1887-88.

Edward Ballinger Taylor was born at Riverton, N. J., on February 6, 1850. He was a son of John Gardiner Taylor and Rebecca Haines (Ballinger) Taylor. His parents were members of the Society of Friends, and he was trained in the tenets of that faith. The ideals of integrity, devotion to duty and kindliness inculcated by that training were reflected in his character through his whole life.

Mr. Taylor was prepared for college at the Westtown, Pa., Boarding School, and in 1866 entered the sophomore class at Haverford College, from which he was graduated in 1869, receiving the degree of Bachelor of Arts. He then entered the Polytechnic College of the State of Pennsylvania, where, in 1870, he was given the degree of Bachelor of Civil Engineering. From the same institution, in 1873, he received the degree of Master of Civil Engineering.

On July 25, 1870, Mr. Taylor entered the service of the Pennsylvania Railroad, as a clerk in the office of the superintendent of the Middle Division, at Harrisburg, Pa. His efficient service won rapid advancement, and in September, 1871, he was promoted to the position of supervisor, and six months later, on March 1, 1872, was appointed assistant engineer of the Middle Division. He continued in that office until January 1, 1875, when he was transferred to a similar position on the Pittsburgh Division.

On July 24, 1876, just six years after entering the service of the Pennsylvania Railroad, he was made superintendent of the Lewistown

Division, with headquarters at Sunbury, Pa., where he remained until January 1, 1879, when he was transferred to the superintendency of the West Penn Division. On September 1, 1879, he was transferred to the Lines West of Pittsburgh, and made superintendent of the Pittsburgh, Cincinnati & St. Louis Railway. He was promoted on April 1, 1888, to the position of general superintendent of the Northwest System, and on March 1, 1890, to that of general superintendent of transportation of the entire system of the Lines West of Pittsburgh.

On December 27, 1901, Mr. Taylor was elected a director and fourth vice-president of the Pennsylvania Company and of the Pittsburgh, Cincinnati, Chicago & St. Louis Railway Company. On January 9, 1907, he became third vice-president, and on February 1, 1914, second vice-president, in charge of the Treasury and Accounting Departments. He also served as president, vice-president or director of 52 subsidiary or affiliated companies of the Pennsylvania System. On March 1, 1920, having attained the age of 70 years, he was, in accordance with the provisions of the Pension Department of the Pennsylvania System, retired from active service.

In addition to his duties as an officer of the Pennsylvania Railroad, Mr. Taylor was for more than 25 years a director of the First National Bank of Sewickley, Pa., and was for some time a director of the Second National Bank of Pittsburgh, Pa., and, after its merger, of the First-Second National Bank of Pittsburgh, Pa.

At the time of his death, Mr. Taylor had been for many years a resident of Sewickley, Pa., and had always taken a keen interest in its needs and activities. Since 1891 he had served as a member, and since 1895 as president, of its Board of Water Commissioners, and it was due largely to his efforts and guidance that the Sewickley water supply was brought to its present status as one of the best and most economical in the State of Pennsylvania. He was one of the original members of the Board of Trustees of the Sewickley Valley Hospital and of the Sewickley Young Men's Christian Association, and took an active part in the work of both institutions. He had served as president of the corporators of the Sewickley Cemetery and of the Edgeworth Club. He was a member of the Allegheny Country Club, the Pittsburgh Club, and the Bankers Club of New York. He was also a member of the American Academy of Political and Social Science, and of the Pittsburgh Academy of Science and Art.

He was a charter member of the Engineers' Society of Western Pennsylvania, and was president of that Society in 1886, and a director in 1887 and 1888. He was also a member of the American Society of Civil Engineers since 1884.

Although Mr. Taylor never forsook his allegiance to the Society of Friends, he was for many years a communicant of St. Stephen's Protestant Episcopal Church in Sewickley. He served as a vestryman and as a member of the Building Committee of this church, and was largely instrumental in securing the replacement of the old frame building with the present handsome stone edifice. In his later years he attended the Sewickley Presbyterian Church, of which he was twice elected a trustee.

Mr. Taylor was married in 1872 to Miss Marianna Satterthwaite, of Oxford Valley, Pa., by whom he is survived. He also leaves three daughters, Mrs. Charles A. Woods, Miss Bertha A. Taylor and Miss Rebecca W. Taylor, all of Sewickley, and one son, Edward B. Taylor, Jr., Assoc. M. Am. Soc. C. E., superintendent of the Marietta Division of the Pennsylvania Railroad, with headquarters at Cambridge, Ohio.

It seems not inappropriate to close this memoir with a quotation from the editorial columns of a local paper—a fitting tribute to the regard in which Mr. Taylor was held by those among whom he lived and worked:

"There are but few men in the Sewickley Valley whose death would be so great a public loss as is that of Edward B. Taylor. Known and liked in a personal way by every one, he was regarded by all with a most unusual respect because of his long and valuable service to Sewickley and to the Valley. The same skill, knowledge, broad vision and safe judgment which brought him pre-eminence in the management of a great railroad system's affairs had for many years been placed freely at the service of his home community and its needs, and have been instrumental in contributing much to its welfare and will contribute much more in the future as improvement plans not yet brought to completion are worked out by other hands. Few men have given so freely, so effectively and so unobtrusively of their time and wisdom in a constructive way to the guiding and betterment of public undertakings in their home communities, and Mr. Taylor's death is a loss indeed to this Valley."

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PROCEEDINGS

OF THE

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

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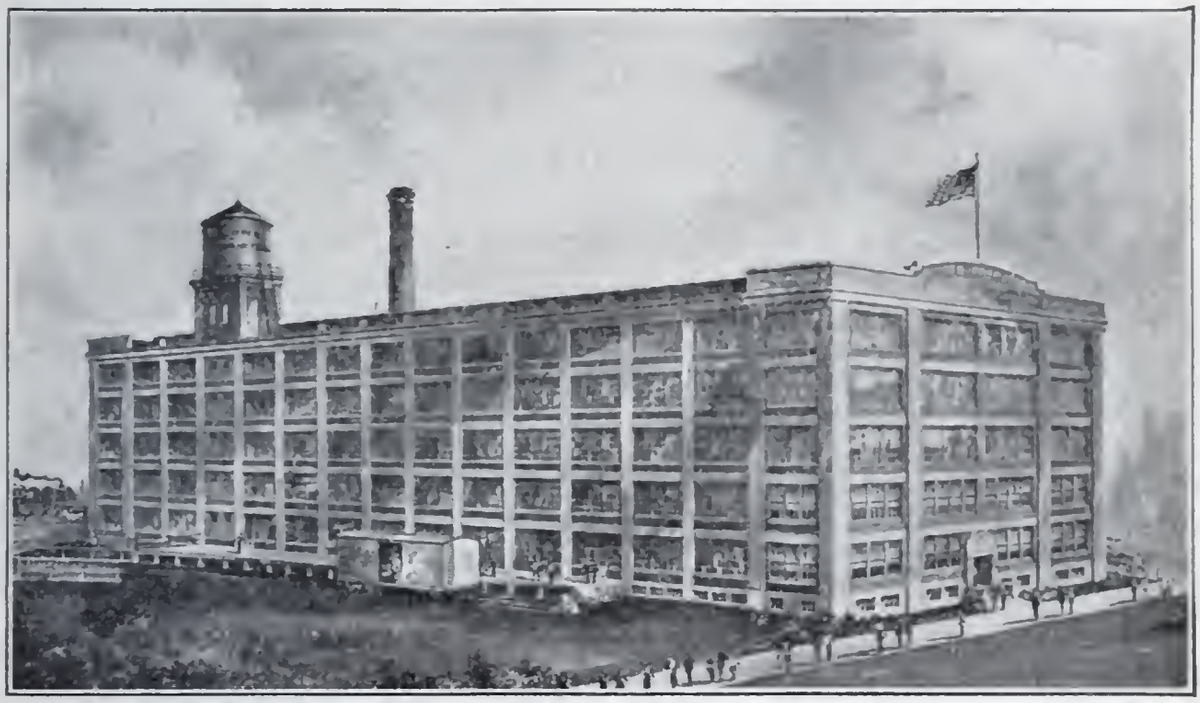

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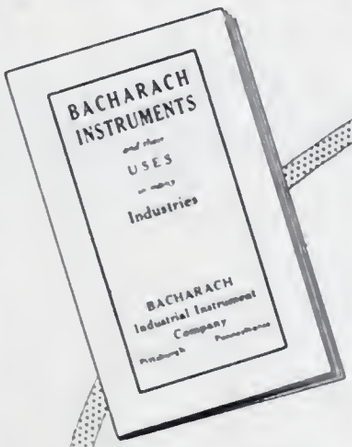

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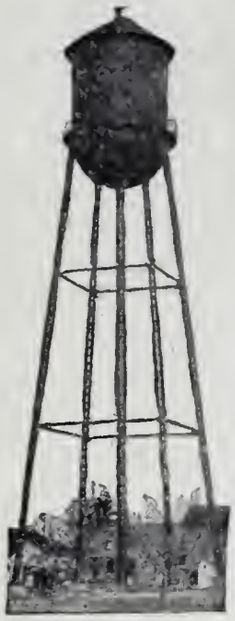

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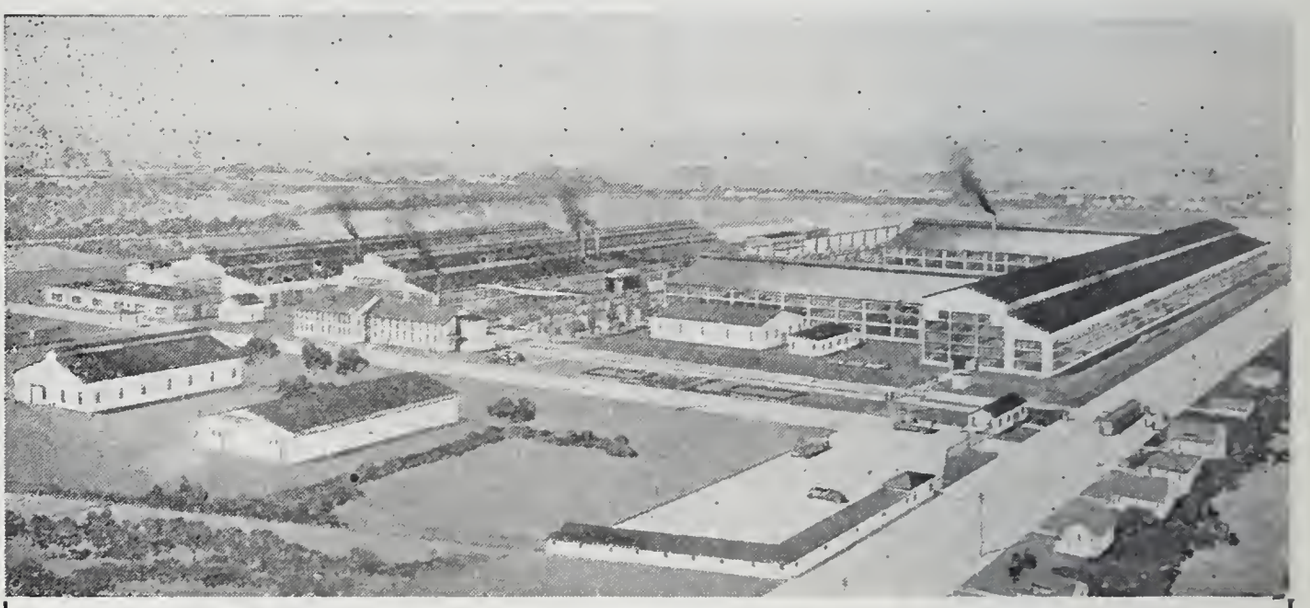

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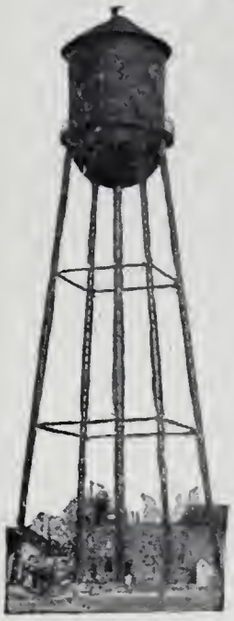

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Members of the Engineers' Society of Western Pennsylvania are invited to visit and study this system. We will be glad to explain its practices and advantages to anyone.

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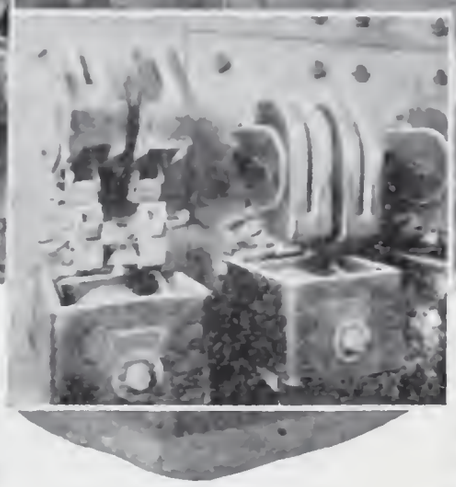

900-ampere line-contactors (above) controlling a 150-h.p., 230-volt d-c. motor operating the front table of a 110-in. plate-mill. They have operated over 1,500,000 times. Maximum rate of operation is about 30 times a minute. The stationary-tips last for about 500,000 operations and the moving-tips last for about 750,000 operations.

600-ampere line-contactors (at left) controlling a 150-h.p., 230-volt d-c. motor operating the back table of a 110-in. plate-mill. The stationary-tips last for about 550,000 operations and the moving-tips last for about 800,000 operations.

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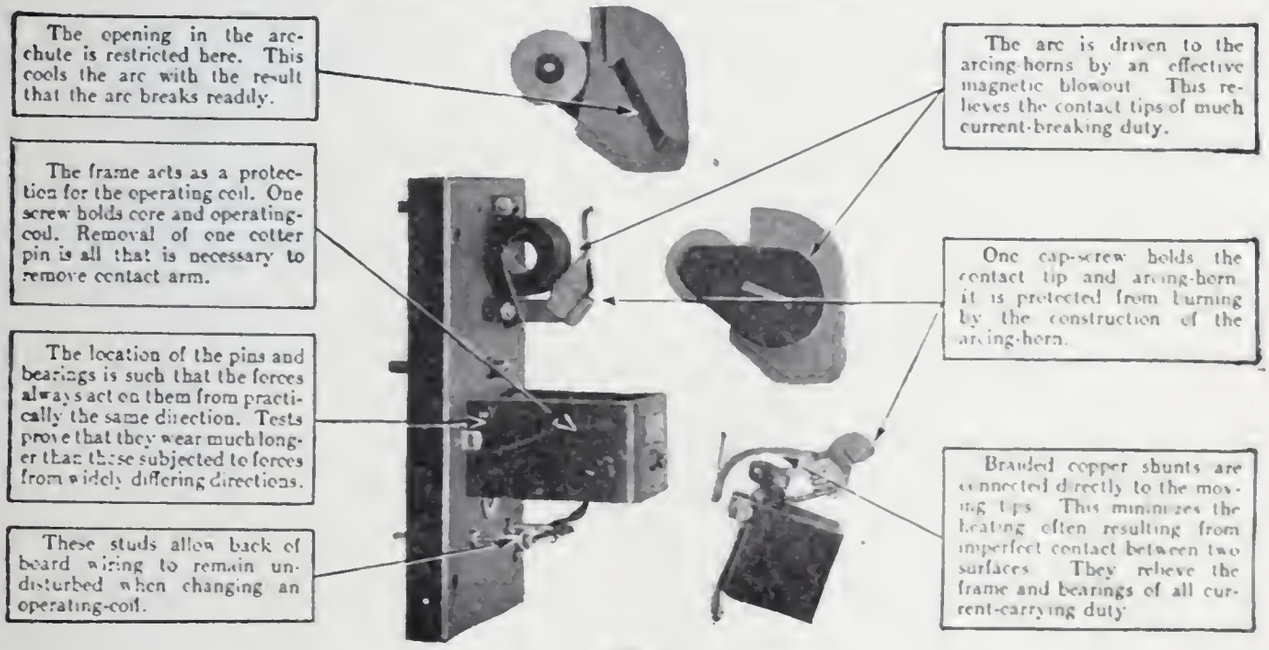
Bent-Frame Type Contactor—Disassembled View.



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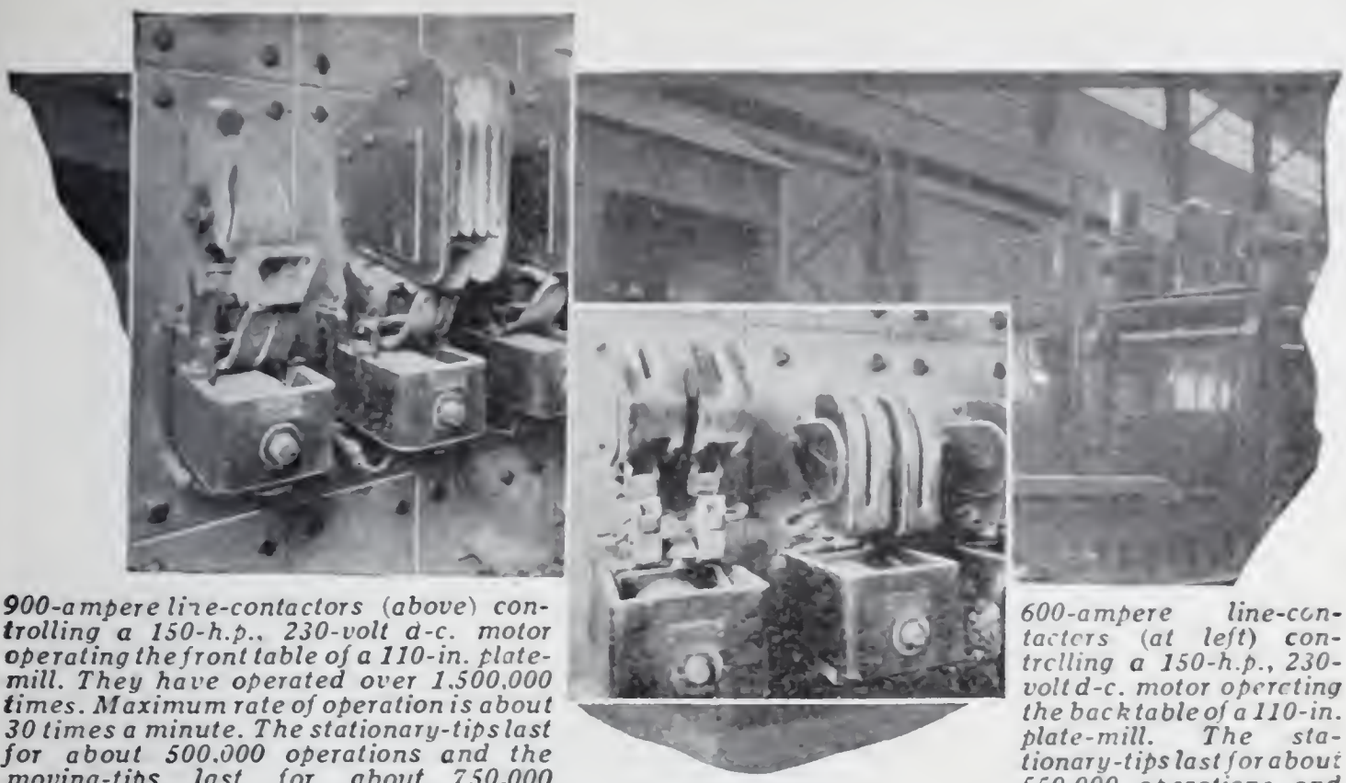

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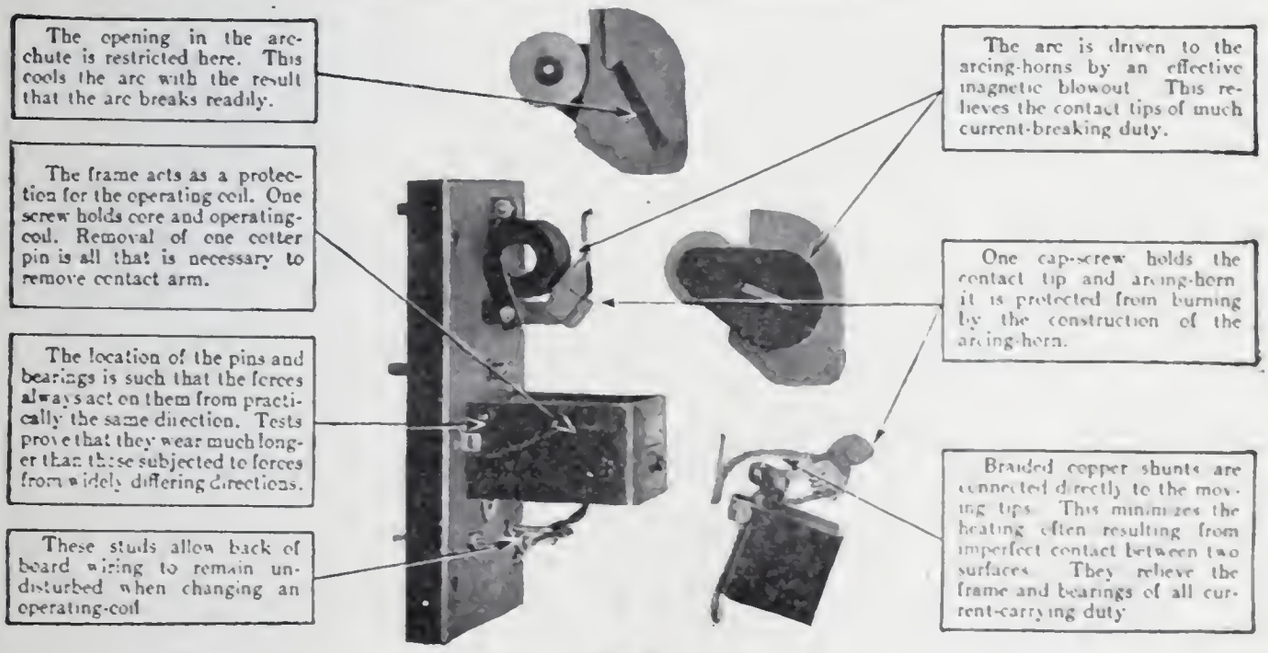

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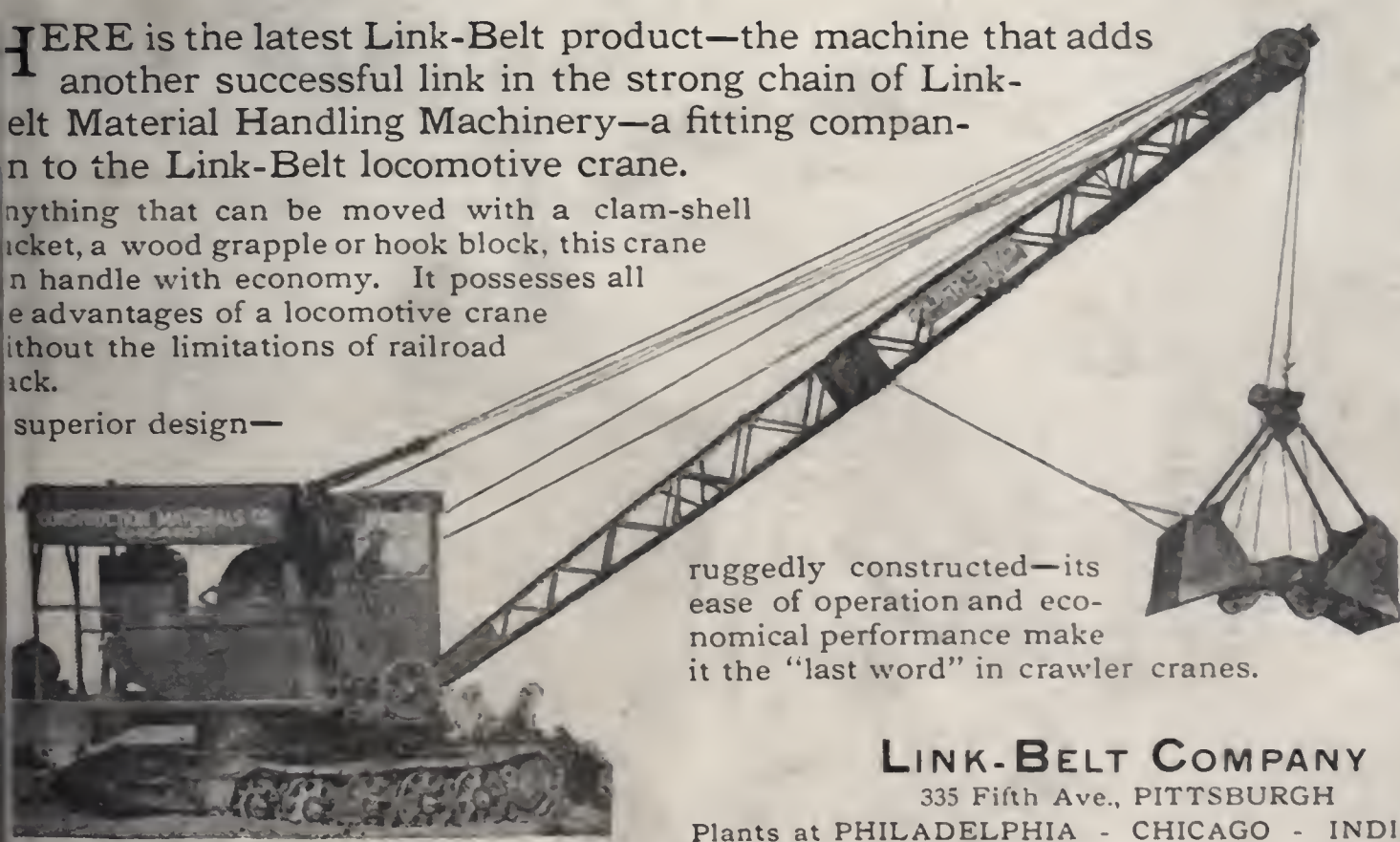

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